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The Swedish Deep-Sea Expedition

HANS PETTERSSON[1]

INTRODUCTION

CUT OFF from active work at sea during the Second World War, Swedish oceanographers devoted their efforts largely to improving the technique of deep-sea oceanography. The raising of long and undisturbed sediment cores from great depths appeared to us to be an especially desirable development. Very little advance had been made in coring methods during the half century which elapsed between the cruises of the "Challenger" and of the "Meteor." In the mid-thirties C. S. Piggot of the Carnegie Institution, Washington, D. C., succeeded in obtaining cores between 1 and 3 meters long from great depths by firing a coring tube vertically downward into the sea bottom with an exploding charge (Piggot, 1936: 207). The chief difficulty in this method was the friction between the column of sediment and the interior wall of the coring tube. Recently an attempt to overcome this difficulty was made by utilizing the high pressure at great depths to operate a "vacuum core sampler" (Pettersson and Kullenberg, 1940, 1941). An undisturbed core 14 meters in length was raised by means of this instrument in the Gullmar Fjord on the west coast of Sweden in 1942. Shortly afterward Kullenberg developed the "piston core sampler," by means of which an undisturbed core 20.3 meters in length was raised from the Gullmar Fjord in 1945 (Kullenberg, 1947). In this device, by trigger action, the entire heavy steel coring tube with attached weights is automatically released on approaching the bottom and sinks down into the sediment. The main wire cable from which the coring tube is suspended is stopped abruptly as the coring tube and weights are released to sink into the sediment. A piston originally at the lower end of the coring tube and attached by an internal wire to the main cable is kept motionless while the coring tube descends around it. Because of the high pressure, the immovable piston immobilizes the column of sediment beneath it as it is cut out by the corer. A view of the piston core sampler suspended alongside the research vessel is shown in Figure 1.

In the spring of 1946 the Swedish government permitted the research vessel "Skagerak" to be used on a trial cruise to the western Mediterranean during which the piston core sampler proved its worth. Cores 8 to 15 meters

FIG. 1. The Kullenberg piston core sampler about to be hauled aboard the "Albatross."

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in length were raised from depths between 1,600 and 3,600 meters. In many of these cores numerous zones of coarse particles, largely of pyroclastic origin (volcanic ash), were found intercalated in the ordinary sediment, thus giving an unrivaled record of the volcanic activity in the vicinity during historic and prehistoric time (Pettersson, 1946). A few of these cores have since been subjected to various physical, chemical, and biological analyses. In addition to the standard analyses, the cores were examined for pollen and radium content (Pettersson, *et al.*, 1948). Study by Dr. Fred Phleger of the Woods Hole Oceanographic Institution of the Foraminifera contained in different layers of three cores from the Tyrrhenian Sea indicates that considerable change in the temperature of the surface water has occurred, which incidentally makes it highly probable that the span of time required for the deposition of these organisms extends well back into the last glaciation (Phleger, 1947).

Another Swedish invention tested during the same cruise was developed by Professor W. Weibull of the Bofors Armament Works. This device records, by means of hydrophones and an oscillograph on board the ship, the time lag between echoes from the surface of the sediment and from transition layers below this surface. The echoes are initiated by exploding depth charges at depths of 100 meters or less. With this instrument a maximum thickness of the sedimentary carpet was found in the center of the Tyrrhenian Sea where, below a water layer of 3,600 meters, the sediment appears to have a thickness of nearly 3,000 meters (Weibull, 1947).

THE PRESENT EXPEDITION

The interest evoked in our native city of Göteborg by these new tools of deep-sea research, and by the promise they give of a new grip on the unsolved problems of the ocean bed, made it possible for me to obtain, from private donors, the extensive financial backing required for an all-Swedish circumnavigating cruise (Pettersson, 1947: 399). Altogether about 2 million Swedish kroner (more than one-half million dollars) have been given to the Royal Society of Göteborg (Göteborgs Kungl. Vetenskaps och Vitterhetssamhäle), which nominated a committee for planning and organizing the cruise. The great difficulty of finding a ship suitable for the expedition was happily overcome through the generous offer of the great Broström Shipping Combine of Göteborg to lend us their new training ship, the 1,450-ton motor schooner "Albatross," at net running costs for the duration of a 15-month cruise. They also gave permission to install nine laboratories, work shops, refrigeration machinery, and cold storage rooms, besides cabins and a mess room for the scientific and technical staff (air conditioned for work in the tropics) all set up within the space normally used for cargo. The "Albatross" is shown in Figure 2. Thanks to wholehearted co-operation from great Swedish industries, a specially constructed, electric deep-sea winch with an electric power station of 140 kilowatts and other necessary equipment were completed in time. A view of a portion of this winch is shown in Figure 3. The refitting of the ship was carried out at the Lindholmen Shipyard in Göteborg where the "Albatross" had been built. The shipyard work was done at a fraction of the normal cost, thanks to the generosity of the owner of Lindholmen.

The scientific and technical staff is comprised of ten men. Besides the author they are: Dr. Börje Kullenberg, oceanographer and inventor of the piston core sampler; Dr. Nils Jerlow, oceanographer and specialist on submarine light and on the transparency of sea water; Dr. Fritz Koczy, oceanographer and specialist on radioactivity and submarine photography; Leif Bruneau, chemist; Dr. Gustaf Arrhenius, geologist; Viggo Wenzel, depth-charge soundings and short-wave specialist; A. Jonasson, chief mechanic; and K. Pettersson, assistant in the sediment work. Dr. John

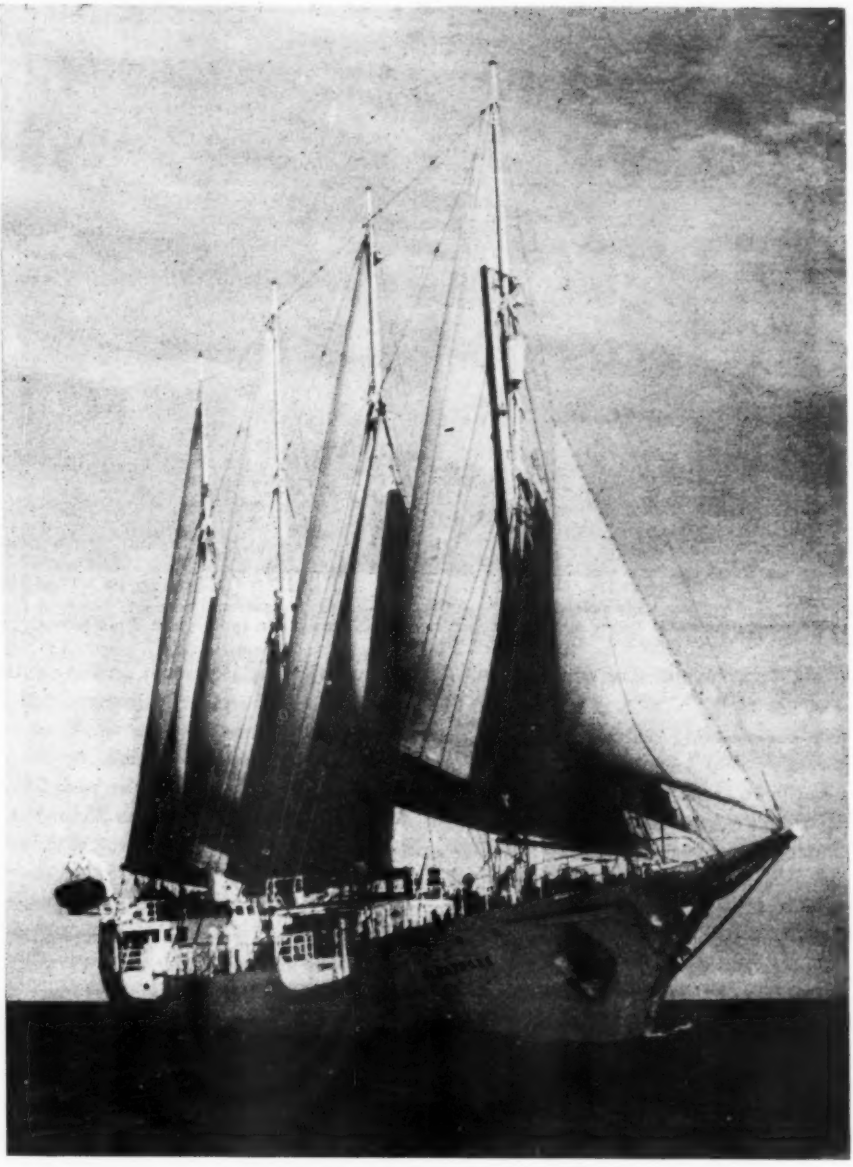


FIG. 2. The "Albatross" under full sail.

Eriksson, surgeon to the expedition, was in charge of the biological work during the first part of the cruise and headed botanical excursions on shore. The ship is most ably commanded by Captain N. Krafft and officers. The total number of non-scientific personnel is 24,

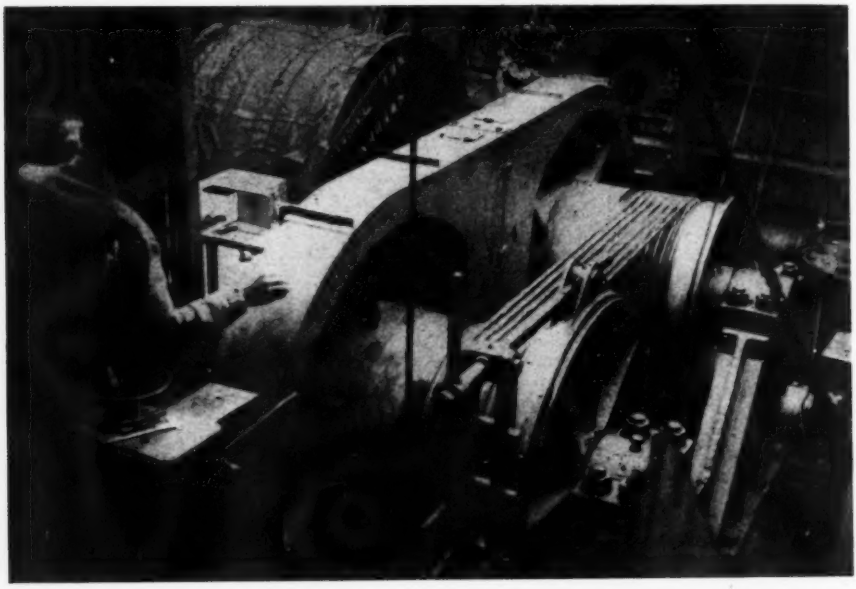


FIG. 3. The deep-sea winch aboard the "Albatross." Only the power drums are shown in the photograph; the 8,000 meters of steel cable are stored on a third great spool which is not shown.

including 12 apprentices between 17 and 21 years of age.

Since our sounding gear is very heavy (approximately 1,500 kilograms), and is carried by a steel-wire cable 8,000 meters in length, a very powerful electric winch capable of raising and lowering a load of over 10 metric tons at a maximum speed of 100 meters a minute was specially built for the cruise. In order to work such heavy gear undisturbed by wind waves and ocean swell, the route to be followed was chosen so as to fall mainly within or near the region of equatorial calms where, fortunately, the sea bottom offers problems of special interest. Our original plan was to begin with a tour of the north Atlantic Ocean down to the equator. Because of unavoidable delay in starting, postponed from the beginning of March to the beginning of July, and the necessity of avoiding the hurricane season in the West Indies and the southwest monsoon in the western Indian Ocean, it was necessary to take a short cut from Madeira to Martinique and from there to Cristobal, where we arrived on August 19. After necessary readjustments had been carried out on our deep-sea winch, in which we were most generously assisted by the Naval Command of the Canal Zone, we passed through the Panama Canal on August 26, and on the following day we left Balboa on a WSW course.

IN THE ATLANTIC

On our way across the Atlantic we had opportunities for testing our gear. Between Madeira and Cristobal eight cores varying in length from 10 to 15 meters were obtained. Most of them consisted of typical red clay, which in the lower levels was considerably tougher than in the upper layers. The greatest depth from which a core was raised was nearly 6,000 meters. As long as we had very calm weather or were running before a moderate sea and swell our deep-sea echo sounder, specially constructed for the cruise by the Marine Instruments of London, gave legible records down to 6,000 meters. The record often became

illegible when we moved against head-winds or an adverse swell because of air bubbles interfering with the ultrasonic beam. Even with this limitation, which results largely from the shallow draught of the "Albatross," the echograph was most useful for our coring operations. The bottom profile showed an astonishing ruggedness even at great depths. Perfectly even surfaces extending over greater distances than a few nautical miles were rarely met in the open Atlantic. A curious rise or fall of the bottom profile by "steps," 20 to 50 fathoms and often considerably more in height, suggestive of faults across our course is quite frequent in the records. Professor Weibull, who personally followed the cruise to Cristobal, found distinct echoes from a "bottom below the bottom" corresponding to a thickness varying between 300 and 2,500 meters, i.e., values comparable to those found in the Mediterranean from the "Skagerak" in 1946.

IN THE PACIFIC

From Balboa we steered toward the Galapagos group (see map), raising sediment cores and taking a few oceanographic series under way. In the Bight of Panama a few hauls in 750 and 1,500 meters, respectively, were made with our large ring net 2 meters in diameter in which catches of weird-looking bathypelagic fishes and invertebrates were brought up.

The cores taken here were greenish-gray and rich in organic remains. In one case there was a distinct smell of sulphuretted hydrogen from the lower parts of the core. Near the Galapagos the sediment was of a light greenish color, was rich in foraminiferal tests, and in one case zones of dark volcanic ash were found in the lower levels.

Our purpose in stopping at the Galapagos was twofold. While the men aboard the ship investigated the cool upwelling water south of the islands, which is rich in plankton, and took sediment cores from the bottom there, five of us went ashore on uninhabited James Island where we spent five unforgettable days collecting plants for our great Swedish authority on the Pacific island flora, Professor Carl Skottsberg of Göteborg.

From James Island the "Albatross" followed a course to the WNW which afforded means for a complete oceanographic section across the Equatorial Countercurrent, where the two lines of divergence (upwelling water) and the line of convergence (descending water) were quite distinct. The oxygen minimum in intermediate water layers was also very conspicuous. An almost total lack of oxygen, less than 0.02 cc. per liter, was found in a depth of 150 meters as far north as latitude 14° 13′ N, longitude 120° 25′ W. Close to the 18th parallel north, the "Albatross" turned south, crossing the Equatorial Current System a second time during which we repeated the observations by water sampling in different depths and raising cores from the sea bottom. The sediment was mainly of the red clay type, but near the equator calcareous sediments appeared which were rich in Foraminifera. Curious signs of stratification were also manifest. A great impediment to our coring operations, even at great depths, was the frequent occurrence of hard bottom which the core samplers could not penetrate. In a couple of cases this led to partial or total loss of the corer. In two cases at least, fragments of basaltic rock caught in the bit of the core sampler proved the obstacle to have been a lava bed covered by a thin veneer of sediment. Similar difficulties occurred also near Nukuhiva in the Marquesas. A botanical excursion was made to the high Tovii Plateau of Nukuhiva where bore kernels were taken from one of the rare peat bogs known in the tropics for future analytical examination for pollen. Between Nukuhiva and Tahiti, where we arrived on October 24, our crop of sediment cores was very meager because of the hard bottom.

The sounding of sediment thickness by depth charges gave results different from those found previously in the open Atlantic Ocean, in the Mediterranean, and in the Caribbean Sea. Virtually no definite signs of reflecting layers situated at more than 200 meters below the

surface of the sediment were obtained. On the other hand, distinct reflexes from depths varying between 60 and 180 meters were repeatedly obtained. In one case where the corer had been stopped by a superficial layer of lava, distinct reflexes from depths similar to those mentioned in the sentence above were obtained, which indicates that the superficial layer of lava is evidently not impenetrable to the acoustic waves recorded by our hydrophones.

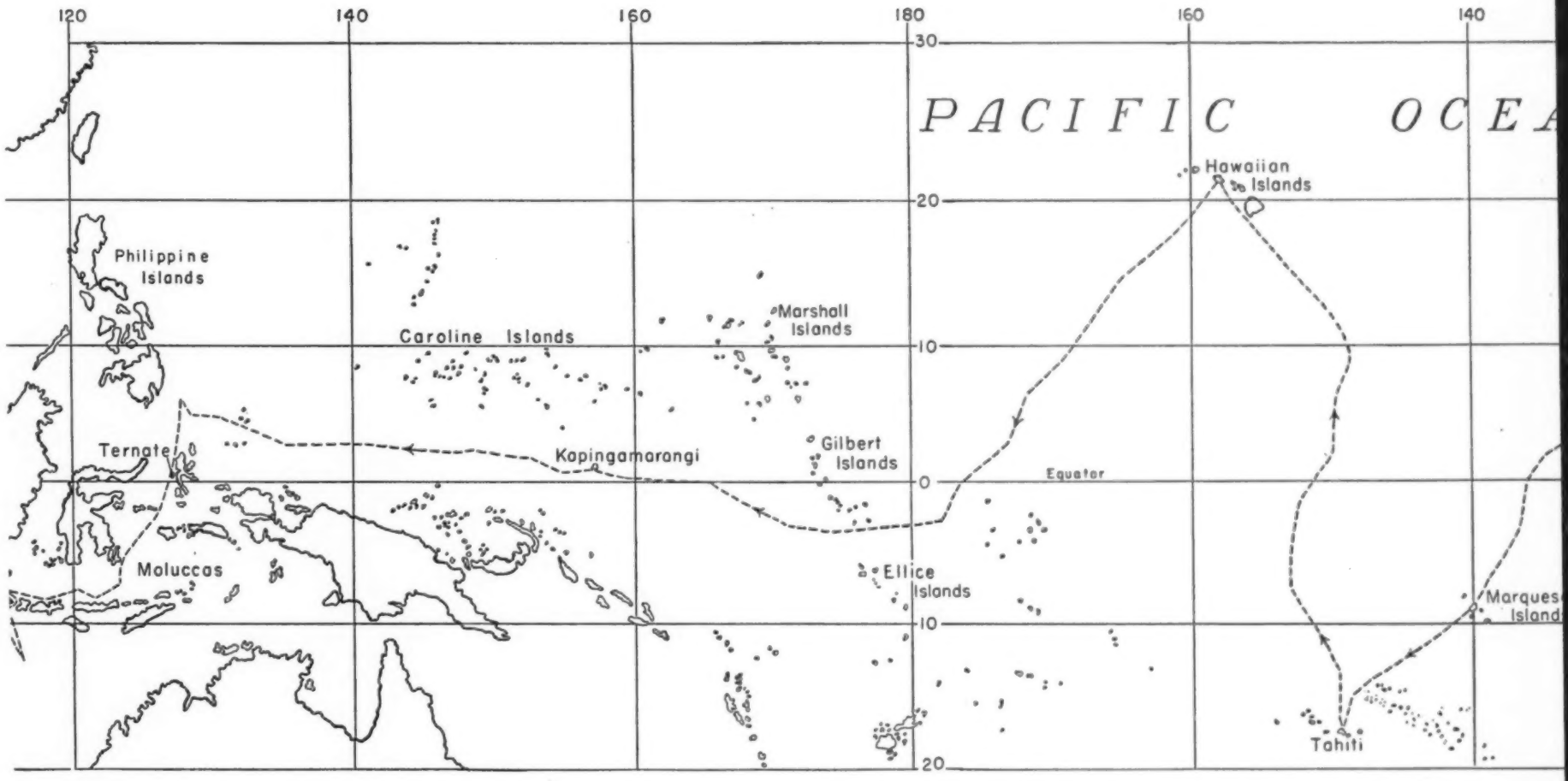
After a pause of 10 days in Papeete the "Albatross" set out on November 2 on a northerly course for Hawaii. Oceanographic series across the Equatorial Current System were made here also, with results very similar to those made previously. While under way we had occasion to repeat several of the stations made over 70 years earlier by the famous "Challenger" Expedition, with results corroborating theirs but with a technique of coring which afforded a depth of penetration more than 20 times as great. The cores, varying from nearly pure radiolarian ooze to nearly pure globigerina ooze, displayed highly interesting stratificatons, with white calcareous sediment alternating with a dark brown or a red clay type. It is tempting to ascribe these variations in the composition of the sediment to climatic fluctuations, acting either directly on the surface temperature of the water and its plankton, or possibly causing a displacement of the whole current system as the polar ice caps grew and varied with inevitable effects on the atmospheric circulation. Here also, especially near the Hawaiian Islands, hard bottom interfered with coring operations and led to loss of instruments.

In Honolulu, when we arrived on November 28, we were most cordially received by municipal authorities, by our colleagues at the Bernice P. Bishop Museum and at the University of Hawaii, and also by the Scandinavian colony represented by the Swe-Nor-Den Society making our stay an unmitigated pleasure. We had occasion to lay our results before our colleagues at a round-table conference at the University of Hawaii, and profited greatly from discussions there and from most stimulating suggestions and advice from Dr. T. A. Jaggar, the greatest volcanologist of our time.

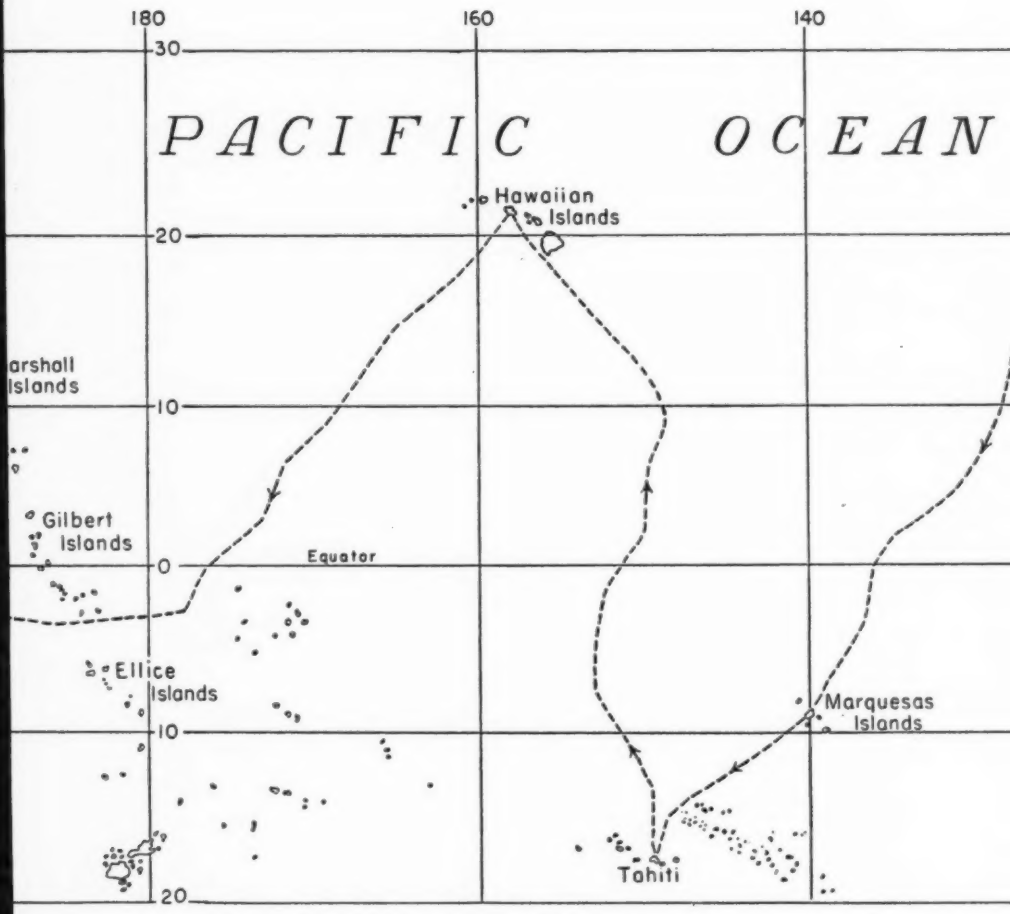
From Honolulu we cruised SW until the equator was crossed, changed our course to WNW, crossed the equator again, and stopped at Kapingamarangi Atoll where submarine light measurements were carried out in the sheltered waters of the lagoon. At the beginning of this segment of our cruise the occurrence of hard bottom again made coring operations difficult, and the bottom profile presented the same rugged and hummocky features as in the eastern and central Pacific. Farther west the bottom became more even and more amenable to both coring and to sediment soundings by depth charges. However, adverse winds, to which the "Albatross" is rather susceptible because of her low-powered auxiliary Diesel engine, made our progress slower than we expected.

In general, the cores taken along our westerly course near the equator were of calcareous sediment, frequently stratified with brownish-gray clay alternating with whitish-gray sediment. Still farther west a greenish color alternated with gray or brown tones. Our last days in the Pacific Ocean were devoted to hydrographic series and soundings in the southernmost part of the Mindanao trench. Here a core raised from the maximum depth of 7,700 meters had a length of only 4 meters, the core sampler having been stopped by a layer of coarse sand rich in volcanic particles! An attempt to raise a core from a still greater depth with an extra wire cable attached to the lower end of our 8,000 meter steel cable failed when the extra wire snapped after the corer was on its way up. The instrument and its precious content were lost.

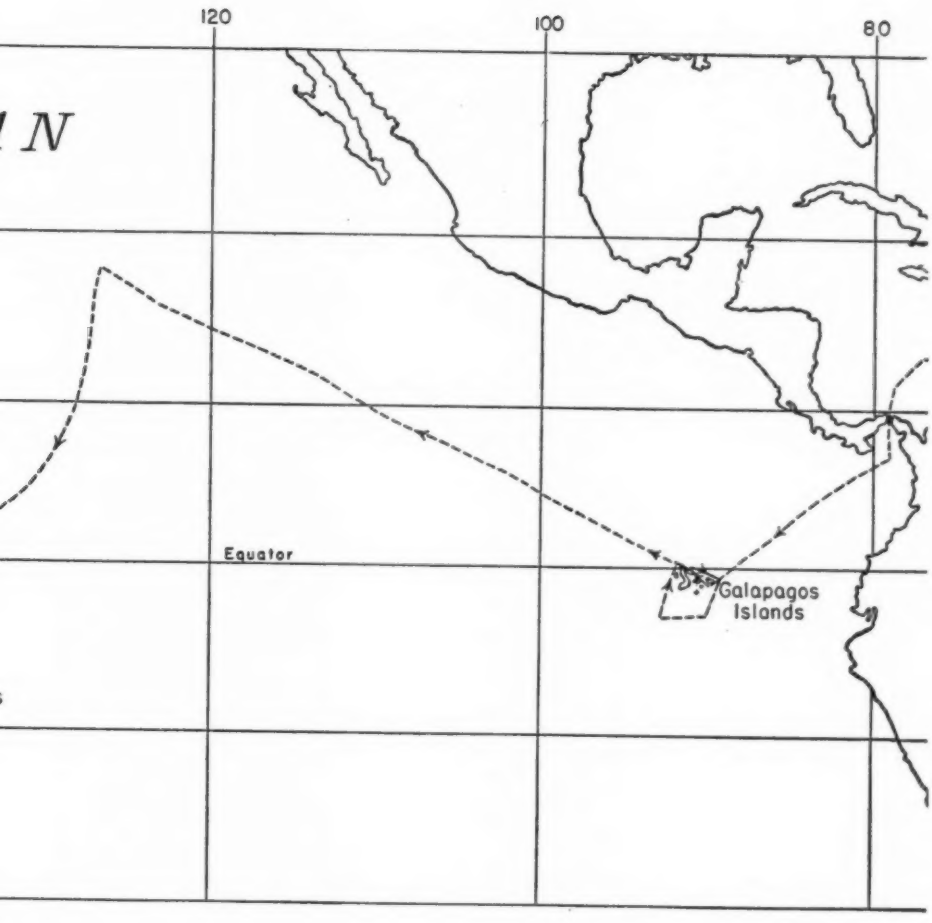
Faint but legible echograms were taken at cross sections over the trench in latitude 5° 20′ N. The results prove that the depths given in the Snellius charts are several hundred meters too great. Attempts to measure the sediment thickness in the trench failed because the ruggedness of the bottom profile produced spurious echoes which obscured any deeper



Route of the Swedish Deep-Sea Expedition research ship "Albatross," in the Pacific Ocean, 1947–1



oute of the Swedish Deep-Sea Expedition research ship "Albatross," in the Pacific Ocean, 1947–1948.



8.

echoes from transition layers below the surface of the sediment.

Steering south from the Mindanao Deep we finally reached the idyllic harbor of Ternate on January 26, 5 months less a day after our start from Balboa. Our cruise across the Pacific was finished.

SUMMARY OF RESULTS

During our Pacific cruise 57 cores with an integral length of nearly 500 meters have been taken, most of which display more or less distinct stratification. In most, but not in all, cases, the sediment profiles raised by means of the long piston core sampler have been supplemented by cores from the surface layers taken by means of a short core sampler of Dr. Phleger's construction and kindly loaned by him for the duration of the cruise.

According to the technique developed by Dr. Kullenberg, the cores are extricated from thin lining tubes 70 centimeters in length inside the steel coring tube and, after a cursory examination on board, are wrapped first in briophane and then in pergament paper. These wrapped cores are introduced into aluminum tubes filled with molten paraffin wax and stoppered, after which they are placed in cool storage, between 5° and 8° C., pending analysis after our return to Sweden. Experience shows that cores preserved in this manner remain practically unchanged indefinitely.

Sediment soundings by depth charges have been carried out at 75 different positions, where in most cases, two depth charges were set to explode at different depths (500 and 2,500, 4,500, or 6,500 meters). Only between Balboa and the Galapagos were reflexes recorded from depths below the surface of the sediment sensibly deeper than 300 meters. For this striking difference between our results in the Atlantic and in the Pacific, no explanation can yet be offered.

Four complete hydrographic sections have been made across the Equatorial Countercurrent System, yielding results similar to those indicated above. When worked up from the dynamic point of view these sections, supplemented by frequent bathythermograph soundings between the stations, will afford valuable material for the study of the Equatorial Countercurrent and the accompanying strips of convergence and divergence.

At a few deep stations large-volume water samples of 25 liters were taken from different depths for analysis for radium (by the $BaSO_4$ Mitreissreaktion) and uranium (by fluorescence). Such analyses are necessary for confirmation of the ionium precipitation hypothesis set forth by the author in 1936 (Pettersson, 1937), and subsequently substantiated through the work of C. S. Piggot and W. D. Urry (1939: 405; 1941), and also in order to utilize measurements of radium in the sediment for determining the rate of sedimentation in the upper layers (Pettersson, 1943, 1945).

Optical studies on sea water were carried out, partly by direct measurements of submarine daylight in different spectral ranges down to depths of 100 meters, and partly by photographic methods down to greater depths by means of a pressure-tight submarine camera. In addition ultraviolet components have for the first time been measured near the surface in the open sea by means of a special technique (Johnson, 1946). Finally, the amount of suspended particles at different depths was measured by means of the Tyndall method, using samples obtained with specially prepared water bottles. Interesting results which show the occurrence of distinct maxima of such particles at certain depths were found by these measurements.

The records from our echo sounder have already been referred to. When worked up systematically, results of value both from a bathymetrical and from a morphological viewpoint may be expected. An interesting observation made repeatedly when crossing the bands of convergence bordering the Equatorial Countercurrent was extra reflections on the echogram in depths between 80 and 150 fathoms. These reflections indicate densely packed or-

ganic matter, presumably shoals of fish or other bathypelagic organisms. It is possible that a kind of intermediate fishing grounds along the equator may be made accessible to exploitation along commercial lines through a future development of the midwater trawling net.

Preliminary measurements of the geothermal gradient in deep-sea deposits were made by means of a geothermometer of special construction. The conditions on the bottom as well as those prevailing at the surface, i.e., wind, waves, swell, and currents, necessarily severely restrict the use of this instrument for it has to be plunged down into the deposit to a depth of about 12 meters and remain there until equilibrium with the surrounding temperature has been attained. Only two successful shots could be made in the Pacific Ocean, both giving unexpectedly high values for the geothermal gradient there (between 20 and 30 meters per degree centigrade). A discussion of these results, which indicate a more intense flow of geothermal heat upwards through the ocean bed than one has, for general reasons, been inclined to assume, must be postponed until more data have been obtained.

In summary it may be said that the new technique developed in Sweden for investigating the deep-ocean bed and its sediments has been found to work well in oceanic depths, and it promises a new and fruitful field of work on the border line between oceanography and submarine geology. When our cores have been examined by different kinds of analyses, a task which will require several years to accomplish, new light will be thrown on problems regarding the deep-sea bottom, its morphology, and its sediments and their chronology. For the latter study both foraminiferal analysis and radioactive age determinations are available.

The investigation of the deep-ocean bed, its stratigraphy, and its fauna manifestly calls for co-ordinated efforts on an international scale. In this future work Honolulu, with its famous Bishop Museum and its University of Hawaii, appears destined to become the foremost center of research in the central Pacific Ocean.

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A New Nematode of the Genus *Pseudophysaloptera* from an Okinawan Shrew

DAVID R. LINCICOME AND BAYARD H. MCCONNAUGHEY[1]

INTRODUCTION

TWO SHREWS, identified as *Suncus murinus riukiuanus* (Kuroda), collected on Okinawa Shima, Ryukyu Islands, were examined for parasites in August, 1945. A large number of nematodes were taken from the stomach, peritoneal cavity, connective tissue in axillae of the hind legs, and the pericardial cavity. Two species are probably represented, one of which forms the basis of this report. It was taken from the stomach of each of the two hosts. The writers are indebted to Dr. Frank N. Young[2] for collection and identification of the shrews.

Specimens were studied largely as wet whole mounts in glycerine or lactophenol. The pattern of the caudal papillae in the male was determined by dissection of more than a dozen specimens. The terminal portion of the body was severed just anterior to the bursa and removed to a glass slide in lactophenol. After removal of the membranous bursa the tail was flattened with ventral side uppermost and held in place by a cover glass. The papillae were then examined under the microscope.

The worms are apparently members of the genus *Pseudophysaloptera* Baylis 1934 (family Physalopteridae Leiper, 1908, subfamily Physalopterinae Railliet, 1893) and have been heretofore unrecognized in the literature. The name *Pseudophysaloptera riukiuana* is therefore proposed.

[1] Department of Medical Microbiology, University of Wisconsin, Madison, Wisconsin, and Department of Zoology, University of California, Berkeley, California, respectively. Manuscript received March 22, 1948.

[2] Assistant professor of zoology, University of Florida.

DESCRIPTION OF SPECIES

Pseudophysaloptera riukiuana n. sp.

General: Body white or opaque; cuticula inflated at anterior end to form a collar in both sexes (see Fig. 1, *d*); two large labia each bearing two prominent submedian papillae and median amphid (see Fig. 1, *d*); three bluntly rounded teeth on the internal surface of each lip, these teeth appearing to originate from a common base in oblique *en face* views. The cuticular surface reflected over the lips appears denticulated as it becomes minutely folded. Esophagus very long and composed of two parts: anterior portion short, muscular; posterior long, glandular. Cervical papillae not observed. Nerve ring located at level of caudal half of the anterior part of esophagus.

Female: Body length, 14.5–28.0 mm.; body width, 0.65–1.2 mm. Collar width, 0.27–0.44 mm. Distance to nerve ring, 0.32–0.97 mm. Distance to excretory pore, 0.7–1.8. mm. Esophagus: total length, 3.38–5.0 mm.; length and width of anterior part, 0.47–0.88 × 0.13–0.22 mm.; width of posterior part, 0.2–0.43 mm. Prominent, saddle-shaped constriction of body marking site of vulvar opening, located in the anterior half, third, or fourth of body. Uterus didelphic in type (see Fig. 1, *c*). Eggs 46–52 μ in length and 26–28 μ in width, with thick hyaline shells and embryonated *in utero*.

Male: Body length, 9.5–14.0 mm.; body width, 0.43–0.7 mm. Collar width, 0.22–0.38 mm. Distance to nerve ring, 0.32–0.42 mm. Distance to excretory pore, 0.47–0.65 mm. Esophagus: total length, 2.49–3.91 mm.; length and width of anterior part, 0.41–0.61 × 0.09–0.18 mm.; width of posterior part, 0.14–0.50 mm. Caudal

papillae (see Fig. 1, *a*) all sessile; 6 pairs on ventrolateral surface posterior to ano-genital opening, 1 large, unpaired, immediately anterior to the ano-genital pore, 2 additional pairs anterior and lateral to this opening. No spicules observed either in free specimens or those *in copulo*.

DISCUSSION

At the time he recognized the genus *Pseudophysaloptera* in 1934, Baylis described *P. soricina* from a species of *Crocidura* collected in the Tanganyika Territory, Africa, which, to the writers' knowledge, is the only species that has been ascribed to the genus.

P. soricina, however, has been recorded from other hosts by other investigators. In 1937 Chen reported this organism from *"Suncus coerulus,"* a shrew from South China. Baylis again recorded *P. soricina* in 1944 "from *Suncus coeruleus kandianus*" in Ceylon. Later Crusz (1946) described the worm from the musk shrew, *"Suncus caeruleus,"* in Ceylon.

The first American finding of this helminth was made by Morgan (MS.), who reported it in the Masked Shrew, *Sorex p. personatus*, and in the Smoky Shrew, *Sorex f. fumeus*, in Tennessee, Kentucky, Wisconsin, and Iowa. A few females tentatively assigned as *P. soricina* by Morgan were also collected from the Short-tailed Shrew, *Blarina brevicauda brevicauda*.

Specific differences in the genus *Pseudophysaloptera* apparently are chiefly concerned with the male organism. The pattern of the caudal papillae on the ventral surface offers a basis for the separation of *P. soricina* and *P. riukiuana*.

Baylis records four pairs of caudal papillae, all of which are typically sessile, post-anal, and lateral. Baylis has kindly sent one of us (D.L.) a pair of the cotype specimens for examination and comparison. We have confirmed four pairs of post-anal papillae (see Fig. 1, *b*), but believe that there may be an additional lateral pair slightly anterior to the ano-genital opening. This pattern is in contradistinction to the six lateral post-anal pairs, the single, large ventromedian pre-anal, and the two lateral pre-anal pairs of papillae in the species at hand.

The expanded cuticular collar at the anterior end of both sexes may be of significance. Baylis (1934) states, "The head (fig. 4) has the same structure as in *Physaloptera*, consisting of two hemispherical lateral lips, followed by a wider neck, the cuticle of which forms a collar." At the same time, Baylis (*op. cit.*, fig. 4, page 347) shows little evidence of what the writers interpret as a "collar" although a relatively small proportion of the extreme anterior end is shown. Examination of a cotype female loaned by Dr. Baylis reveals no prominent inflation such as is present on *P. riukiuana* (see Fig. 1, *e*).

There are other differences in body length, distance to nerve ring, and total length of esophagus that may be related to the degree of contraction of the worms at fixation. The forms under consideration here were generally well fixed and well relaxed. Both specimens loaned by Baylis were in a marked degree of contraction.

Chen (1937) and Crusz (1946) have both recorded *P. soricina* from shrews in China and Ceylon, but their descriptions seem to offer some doubt as to their specific identifications. The papilla pattern of the male in both instances is described as "numerous." Crusz's Figure 5 (page 63) shows at least a dozen large and small papillae in scattered and irregular distribution on each side over the ventral surface. The number and distribution of the caudal papillae of the male are markedly different here from *P. riukiuana*. With reference to this point, in a personal communication under date of March 1, 1948, Baylis stated, "I have examined one of Mr. Crusz's specimens . . . I am not at all convinced that all the small 'papillae' shown in his figures are really papillae at all. I think many of them are subcuticular structures . . . ."

As further evidence of a possible difference between *P. soricina* of Chen and Crusz and the present material, the absence of spicules might be cited. Chen (1937: 428) states, "Spicules

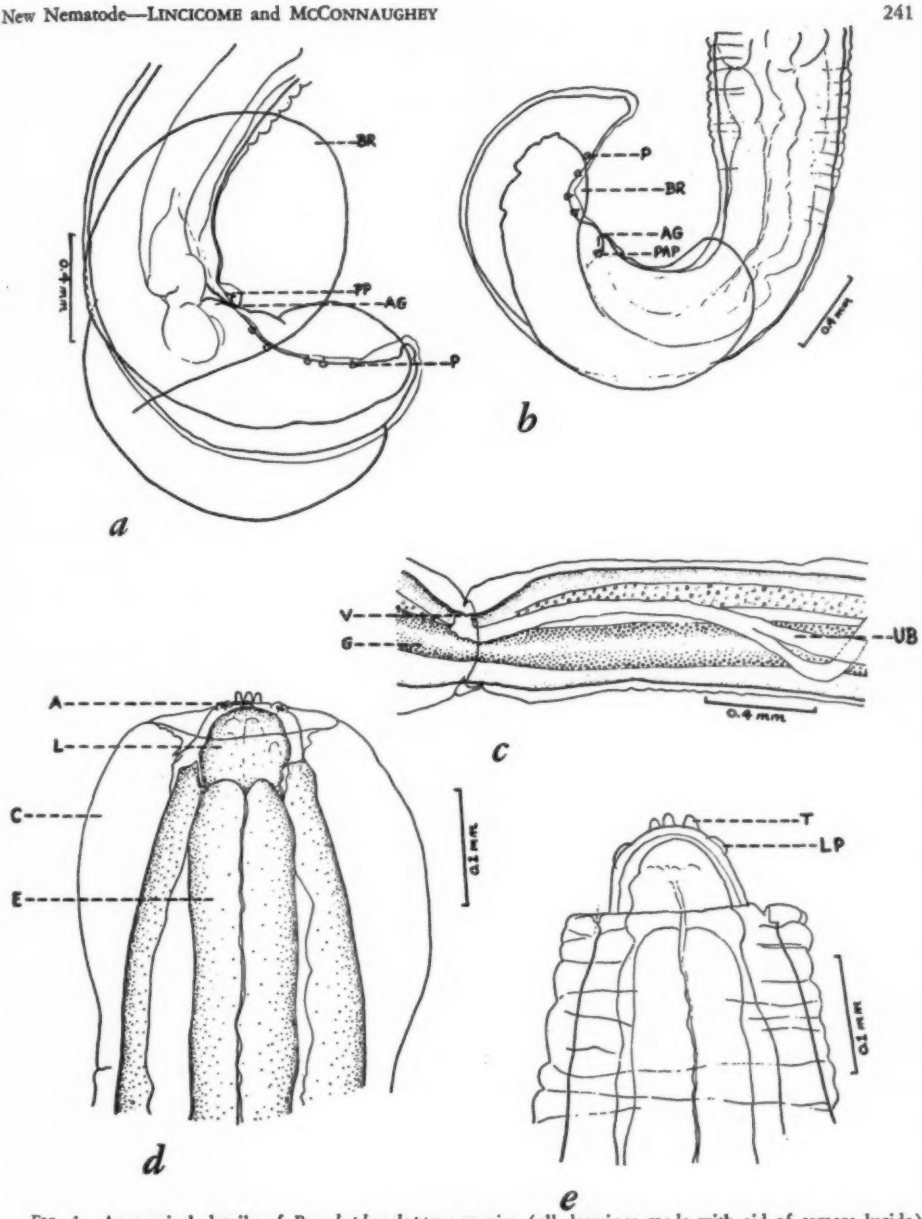

FIG. 1. Anatomical details of *Pseudophysaloptera* species (all drawings made with aid of camera lucida). *a*, Lateral view of posterior end of male *Pseudophysaloptera riukiuana*. (Five post-anal and a single pre-anal papillae are shown. The full pattern [2 pre-anal pairs, 1 single pre-anal and 6 post-anal pairs] could not be demonstrated in every male because of the opaqueness of this area of the body.) *b*, Lateral view of posterior end of cotype male *Pseudophysaloptera soricina* Baylis 1934. *c*, Lateral view of region of vulva of female *Pseudophysaloptera riukiuana* showing didelphic uterus. *d*, Lateral view of anterior end of male *Pseudophysaloptera riukiuana*. *e*, Lateral view of anterior end of cotype female of *Pseudophysaloptera soricina* Baylis 1934.

A, amphid; AG, ano-genital opening; BR, bursa; C, collar; E, esophagus; G, gut; L, lip; LP, labial papilla; P, post-anal papilla; PAP, paired pre-anal papilla; PP, single pre-anal papilla; T, labial tooth; UB, uterine branch; V, vulva.

(?) indistinct, in the form of two barely discernible structures, equal, pointed at both ends, 0.15 mm. long." Crusz (1946) on the other hand states, "A very distinct pair of spicules present in one worm; slender, well 'chitinized,' unequal, pointed anteriorly, and blunt or probably broken off posteriorly. Right spicule 0.231 mm. long, left spicule 0.190 mm. long. No trace of any spicules in the other two worms." In the same personal communication referred to above, Baylis has "carefully examined, with Mr. Crusz, the specimens from which he made his drawing showing 'spicules.' The structures he shows as such are certainly there, and in the position in which they are shown. They appear to be unquestionably *internal,* and not (as I had half expected) lying on the surface of the preparation . . . My own suggestion is that they do not belong to this specimen at all, but to some other nematode (possibly *Castronodus strassenii* Singh, 1934 which occurs in nodules of the stomach of the same host), which had somehow inserted them and had them broken off."

There is no evidence of the presence of spicules in any of the males in the present collection.

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——— 1944. Notes on some parasitic nematodes. *Ann. and Mag. Nat. Hist.* XI, 11: 793–804.

CHEN, H. T. 1937. Some parasitic nematodes from mammals of South China. *Parasitology* 29(4): 419–434.

CRUSZ, HILARY. 1946. Contributions to the helminthology of Ceylon. II. Notes on some parasitic nematodes, with a description of *Anisakis tursiopis* sp. nov. *Ceylon Jour. Sci.* (B) 23 (2): 57–66.

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A List of Scientific Institutions in the Pacific Area

O. A. BUSHNELL[1]

INTRODUCTION

THIS LIST of scientific institutions in the Pacific area is presented with the frank hope that, in its way, it will help in the dissemination of knowledge and the exchange of information upon which the friendship of nations and the peace of the world are built. The Editors of *Pacific Science* believe that most scientists, as should all men, seek peace as earnestly as they do truth; and they believe, too, that, with the world as it is now, scientists and teachers—no matter what their disciplines may be—bear much of the burden of hope which the people of the world have placed upon their leaders in their yearning for peace.

The opportunity to exchange ideas and persons, freely and without constraint, is one of the most important elements in understanding either a people or a nation. Any program or action, then, which can facilitate this exchange, is a useful one. Many such programs have already been initiated, and many more of them are contemplated. The admirable policy of exchanging teachers and students among nations; the programs and aspirations of UN, UNESCO, WHO, FAO; the programs of governments (such as that of the Fulbright Act), of international congresses (such as the Seventh Pacific Science Congress in New Zealand next February), of universities and research foundations, of churches and of organized and private charities; the quiet work of individuals, all are contributing, as wars and treaties never can, to understanding and to peace. The mere presentation of this list of scientific institutions in the Pacific area is a very small step toward this goal, but—if only because no such catalogue has ever been published before—it is felt that the list will be of value to those individuals and institutions throughout the world who may be aided by it in making their larger progress toward that goal.

In the compilation of this list, information was sought direct from sources in each of the countries concerned. Letters of inquiry, asking for the names, addresses, and special qualifications of scientific institutions in each of the countries in the Pacific hemisphere "at which visting scientists might find the facilities (and the invitation) to pursue research in their particular subjects," were sent to the Embassies, Legations, Consulates, and Information Services, in the United States, of each of the Pacific countries. Identical letters were sent to the Embassies, Legations, Consulates, and Information Services of the United States in each of the countries concerned. Similar requests were sent to the Office of the Director General of UNESCO, Paris, and to the Executive Secretary of the United States National Commission for UNESCO, Department of State, Washington, D.C.

The co-operation received in response to these letters of inquiry was amazing and heartening. Answers were received from almost every office addressed, and the information which was requested was freely given by every country, with one expected and regrettable exception. The list as it is published can be assumed to present, along with the facts which were sought, the good will and the interest of the countries represented in it.

[1] Department of Bacteriology, University of Hawaii; Assistant Editor, *Pacific Science*. Manuscript received May 29, 1948.

The list is a selected one, compiled from the many answers received to the letters of inquiry. It probably presents all of the major scientific institutions now functioning in the countries in and around the Pacific Ocean and undoubtedly presents some of the minor institutions as well. Because it is difficult to appraise national vanity (even among scientists, often among diplomats!), and because of my own ignorance of the stature of these institutions in faraway countries, it is possible that some institutions which are unworthy of the distinction have been added to the list, and it is probable that some which should have had their place in the list have been left out. For these errors of judgment or omissions of fact I alone must be held responsible, the while I hope that increasing knowledge of the countries of the Pacific, the dissemination and use of this list, and the cooperation of scientists throughout the world will help to correct them.

The countries included in the list are arranged alphabetically, and the institutions in each country are also arranged according to their alphabetical order. Each entry presents the name of the institution (in SMALL CAPITALS), its address (in roman type), and—where this information is known, or where it is not already evident from the name of the institution—the special qualifications of the institution, or some descriptive summary of its function (in *italics*). For example:

> BERNICE P. BISHOP MUSEUM, Honolulu 35, Hawaii. *Collection, preservation, and study of Hawaiian and Pacific material in ethnology and the natural sciences...*

In the cases of the major universities and some of the research institutions which are equipped with facilities to do research in most of the fields of science, it has not been thought necessary to name each of the departments of the institutions. The word *General* suggests their eminence and their versatility.

On the other hand, the mention of some specialty for an institution does not necessarily mean that its work is confined entirely to the field of that specialty. The specialty listed means only that, in the opinion of the scientists in that institution, or of the cultural attaché evaluating it, or of myself endeavoring to catalogue it, the word used is the one that seems best to describe the work for which the institution is distinguished. It does not mean that no other work, either in related or in different fields, is done there.

The fact that an institution is placed in this list does not mean, furthermore, that it is ready to accommodate visiting scientists immediately. In every instance, a scientist who wishes to pursue research in some institution other than his own must first make personal and definite arrangement with the institution of his choice in order to be certain that the institution possesses facilities which he might use and that he would have the invitation of the institution (or of the country in which the institution is located) to share its facilities. This injunction is particularly true for institutions in those countries which have recently been afflicted with war, or which are still troubled with civil wars, but it applies to all institutions, wherever they may be. The further difficulties of exchange of persons, of funds, of equipment, are so variable that they cannot be mentioned here, but must be left to the patience and perseverance of the individual scientist to surmount.

Spokesmen for many of the countries whose scientific institutions are represented in this list, and for many of the institutions themselves, have stated that they are very much interested in helping visiting scientists and that they would welcome visitors—"always provided, of course, that space and equipment can be found for them." This is the difficulty in almost every country: the welcome and the good will are readily offered, but the great demands made by their own people upon these institutions place a premium upon laboratory space and equipment that all too often cannot meet even the local needs.

Acknowledgments: The assistance of the staffs of the many diplomatic offices and information services and of UNESCO, who helped to provide the information requested of them, has already been acknowledged in private letters to them, but public acknowledgment is recorded here. They are too many to name separately, and, in many cases, so anonymous as to be unknown at all, but their assistance has been so valuable that the list should stand rather as testimony to their work than to my own.

AUSTRALIA

AUSTRALIAN CHEMICAL INSTITUTE, 39 Martin Place, Sydney, New South Wales.

AUSTRALIAN INSTITUTE OF ANATOMY, Canberra, A. C. T.

AUSTRALIAN INSTITUTE OF MINING AND METALLURGY, 309 Little Collins Street, Melbourne, Victoria.

AUSTRALIAN MUSEUM (SYDNEY), College Street, Sydney, New South Wales.

AUSTRALIAN NATIONAL MUSEUM, Canberra, A. C. T.

AUSTRALIAN NATIONAL RESEARCH COUNCIL, Science House, 157 Gloucester Street, Sydney, New South Wales.

BAKER INSTITUTE, Alfred Hospital, Melbourne, Victoria.
Medical research.

BUREAU OF MINERAL RESOURCES, GEOLOGY, AND GEOPHYSICS, Chancery House, 485 Bourke Street, Melbourne, C. 1., Victoria.

BUREAU OF SUGAR EXPERIMENT STATIONS, William Street, Brisbane, Queensland.

COMMONWEALTH FORESTRY BUREAU, Canberra, A. C. T.

COMMONWEALTH METEOROLOGICAL BUREAU, Victoria and Drummond Streets, Carlton, Victoria.

COMMONWEALTH OBSERVATORY, Mt. Stromlo, Canberra, A. C. T.

COMMONWEALTH SERUM LABORATORIES, 45 Poplar Street, Parkville, Melbourne, Victoria.

COMMONWEALTH X-RAY AND RADIUM LABORATORY, University of Melbourne, Carlton, N. 3, Victoria.

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (C. S. I. R.), 314 Albert Street, East Melbourne, C. 2, Victoria. (Inquiries are to be addressed to the Secretary.)

The C. S. I. R. is the largest Commonwealth Government organization, and is extensively subdivided as follows:

ATOMIC PHYSICS RESEARCH, University of Melbourne, Carlton, N. 3., Victoria.

BUILDING MATERIALS RESEARCH, Graham Road, Highett, S. 21, Victoria.

COMMONWEALTH RESEARCH STATION, Merbein, Victoria.

DAIRY RESEARCH SECTION, Lorimer Street, Fishermen's Bend, S. C. 8, Victoria.

DIVISION OF AERONAUTICS, Lorimer Street, Fishermen's Bend, S. C. 8, Victoria.

DIVISION OF ANIMAL HEALTH AND PRODUCTION, Park Street and Flemington Road, Parkville, N. 2, Victoria.

DIVISION OF BIOCHEMISTRY AND GENERAL NUTRITION, University Grounds, Adelaide, South Australia.

DIVISION OF ECONOMIC ENTOMOLOGY, P. O. Box 109, Canberra City, A. C. T.

DIVISION OF ELECTROTECHNOLOGY, National Standards Laboratory, City Road, Chippendale, New South Wales.

DIVISION OF FISHERIES, Box 21, P. O. Cronulla, New South Wales.

DIVISION OF FOOD PRESERVATION AND TRANSPORT, Private Bag, Homebush, New South Wales.

DIVISION OF FOREST PRODUCTS, 69 Yarra Bank Road, South Melbourne, S. C. 4, Victoria.

DIVISION OF INDUSTRIAL CHEMISTRY, Lorimer Street, Fishermen's Bend, S. C. 8, Victoria.

DIVISION OF METROLOGY, National Standards Laboratory, City Road, Chippendale, New South Wales.

DIVISION OF PHYSICS, National Standards Laboratory, City Road, Chippendale, New South Wales.

DIVISION OF PLANT INDUSTRY, P. O. Box 109, Canberra City, A. C. T.

DIVISION OF RADIOPHYSICS, National Standards Laboratory, City Road, Chippendale, New South Wales.

DIVISION OF SOILS, Waite Agricultural Research Institute, Private Mail Bag, Adelaide, South Australia.

FLAX RESEARCH, Graham Road, Highett, S. 21, Victoria.

INFORMATION SERVICE, 425 St. Kilda Road, Melbourne, S. C. 2, Victoria.

IRRIGATION RESEARCH STATION, Private Mail Bag, Griffith, New South Wales.

MINERAGRAPHIC INVESTIGATIONS, c/o Geology School, University of Melbourne, Carlton, N. 3, Victoria.

ORE DRESSING INVESTIGATION, c/o Metallurgy School, University of Melbourne, Carlton, N. 3, Victoria.

RADIO RESEARCH BOARD, c/o Electrical Engineering Department, University of Sydney, Chippendale, New South Wales.

SECTION OF MATHEMATICAL STATISTICS, c/o University of Adelaide, North Terrace, Adelaide, South Australia.

SECTION OF METEOROLOGICAL PHYSICS RESEARCH, 572 Flinders Lane, Melbourne, C. 1, Victoria.

SECTION OF PHYSICAL METALLURGY, University of Melbourne, Carlton, N. 3, Victoria.

SECTION OF TRIBOPHYSICS, University of Melbourne, Carlton, N. 3, Victoria.

WOOL TEXTILE TECHNOLOGY, 314 Albert Street, East Melbourne, C. 2, Victoria.

WALTER AND ELIZA HALL INSTITUTE FOR MEDICAL RESEARCH, Royal Melbourne Hospital, Parkville, Melbourne, N. 2, Victoria.

INSTITUTE OF AGRICULTURE OF THE UNIVERSITY OF WESTERN AUSTRALIA, Nedlands, Western Australia.

INSTITUTE OF MEDICAL RESEARCH OF NEW SOUTH WALES, Royal North Shore Hospital, St. Leonards, New South Wales.

KANEMATSU MEMORIAL INSTITUTE OF PATHOLOGY, Sydney Hospital, Sydney, New South Wales.

MARINE BIOLOGICAL STATION, UNIVERSITY OF SYDNEY, Port Jackson.

MELBOURNE WOMEN'S HOSPITAL, Swanston Street, Melbourne, N. 3, Victoria.
Pathology.

MICROBIOLOGICAL LABORATORY, 93 Macquarie Street, Sydney, New South Wales.

MUNITIONS SUPPLY LABORATORIES, Maribyrnong, Victoria, with branch establishments at Adelaide and Sydney.

MUSEUM OF TECHNOLOGY AND APPLIED SCIENCE (formerly known as the Sydney Technological Museum), Harris Street, Broadway, Sydney, New South Wales.

NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL, Canberra, A. C. T. (Inquiries are to be addressed to the Director-General of Health.)

NATIONAL MUSEUM (VICTORIA), Swanston Street, Melbourne, Victoria.

NATIONAL UNIVERSITY OF AUSTRALIA, Canberra, A. C. T. ("This University is now in the course of being built. Details of organization are not yet available, but research departments of medicine and physics are already being established.") [C.S.I.R., Letter, February 20, 1948.]

PERTH MUSEUM, Beaufort Street, Perth, Western Australia.

QUEENSLAND MUSEUM, Gregory Terrace and Bowen Bridge Road, Brisbane, Queensland.

SCHOOL OF MINES, North Terrace, Adelaide, South Australia.

SCHOOL OF MINES, Ballarat, Victoria.

SCHOOL OF MINES, Kalgoorlie, Western Australia.

SOUTH AUSTRALIAN MUSEUM, North Terrace, Adelaide, South Australia.

TASMANIAN MUSEUM, Macquarie Street, Hobart, Tasmania.

UNIVERSITY OF ADELAIDE, North Terrace, Adelaide, South Australia.
General.

UNIVERSITY OF MELBOURNE, Carlton, N. 3, Victoria.
General.

UNIVERSITY OF QUEENSLAND, George Street, Brisbane, Queensland.
General.

UNIVERSITY OF SYDNEY, Parramatta Road, Sydney, New South Wales.
General.

UNIVERSITY OF TASMANIA, Hobart, Tasmania.
General.

UNIVERSITY OF WESTERN AUSTRALIA, Nedlands, Western Australia.
General.

STATE GOVERNMENTS AND DEPARTMENTS: "Each of the six State Governments of Australia maintains scientific departments or subdepartments which deal largely with scientific problems arising within the State, and which also carry out a considerable amount of routine and other scientific work associated with the laws and regulations of the State. Thus, in each of the States, there is a Department of Agriculture; a Forest Service; a Department of Main Roads; a Mines Department; a Lands Department; and Government Chemical Laboratories, etc. These bodies can render assistance in specialized fields, but direct approach to them would be desirable in all cases." [C.S.I.R., Letter, February 20, 1948.]

Mr. J. E. Cummins, Officer-in-Charge of the Information Service of the Council for Scientific and Industrial Research, writes that "it is not possible to express an opinion as to whether each of the institutions or departments [included in this list for Australia] would be able to provide accommodation for visiting scientists. Unfortunately, the facilities for research in some of the scientific institutions are very limited, and, depending upon the time of visit and the period of this, a definite decision could not be made as a general statement. However, I am sure that all of the Australian research institutions listed would be only too pleased to do their utmost to provide assistance.

"In the specific case of the C.S.I.R.... the Executive Committee of the Council have informed me that they would be glad to welcome visiting scientists in any of their laboratories and would be only too pleased to make facilities available for them. May I suggest, therefore, that... intending visitors should make direct enquiries before visiting Australia and while their plans are still in the formative stage."

This information was received from the Information Service of the Council for Scientific and Industrial Research of the Commonwealth of Australia, 425 St. Kilda Road, Melbourne, S. C. 2, through the assistance of the Scientific Liaison Office of the Australian Embassy, Washington, D. C.; from the British Consulate, Honolulu, T. H.; from the British Information Services, New York; from the American Embassy, Canberra, Australia; and from UNESCO, Paris. February–April, 1948.

BRITISH MALAYA

BOTANICAL GARDENS, Singapore.

COLLEGE OF AGRICULTURE, Kuala Lumpur.

INSTITUTE FOR MEDICAL RESEARCH, Kuala Lumpur.

KING EDWARD VII COLLEGE OF MEDICINE, Singapore.

RAFFLES COLLEGE, Singapore.
General.

RAFFLES MUSEUM AND LIBRARY, Singapore.
Anthropology, archaeology, botany, and zoology of Malaysia.

RUBBER RESEARCH INSTITUTE, Kuala Lumpur.

This information was received from the American Consulate General, Singapore. March, 1948.

CANADA

FISHERIES EXPERIMENTAL STATION, 898 Richards Street, Vancouver, B. C.
Fisheries technology.

PACIFIC BIOLOGICAL STATION, Nanaimo, B. C.
Fisheries, marine biology, oceanography.

UNIVERSITY OF ALBERTA, Edmonton, Alberta.
General.

UNIVERSITY OF BRITISH COLUMBIA, Vancouver, B. C.
Agriculture, bacteriology, biophysics, geology, geophysics, marine algae and oceanography, nuclear physics, preventive medicine, spectroscopy.

UNIVERSITY OF MANITOBA, Winnepeg, Manitoba.
Botany, chemistry, geology, zoology.

UNIVERSITY OF SASKATCHEWAN, Saskatoon, Saskatchewan.
Physical chemistry, medicine, physics.

This information was received from the University of British Columbia, Vancouver, B. C., and from the National Research Council of Canada, through the Canadian (N. R. C.) Scientific Liaison Office, Washington, D. C. January–April, 1948.

CANAL ZONE

CANAL ZONE BIOLOGICAL AREA (formerly Barro Colorado Island Biological Laboratory), Balboa, Canal Zone.
Biological research.

CANAL ZONE BRANCH, BUREAU OF ENTOMOLOGY, U. S. DEPARTMENT OF AGRICULTURE, Balboa, Canal Zone.

CANAL ZONE EXPERIMENT GARDENS, Pedro Miguel, Canal Zone.
Botanical research.

This information was received from the American Embassy, Panama, R. P., and from UNESCO, Paris. January–April, 1948.

CHILE

AMERICAN SOCIETY OF AGRICULTURAL SCIENCES, CHILEAN CHAPTER, Departamento de Genetica Fitotecnica, Ministerio de Agricultura, Santiago.

INSTITUTO BACTERIOLOGICO DE CHILE, Borgoño 1470, Santiago.

INSTITUTO BIOLOGICO Y ESTACION EXPERIMENTAL DE LA SOCIEDADE NACIONAL DE AGRICULTURA, F. Lazcano 1502, Santiago.

INSTITUTO PANAMERICANO DE INGENIERIA DE MINAS Y GEOLOGIA, Casilla 9228, Calle Austinas 1111, Santiago.

MUSEO ARAUCANO, Temuco.

MUSEO NACIONAL DE HISTORIA NATURAL, Quinta Normal, Santiago.

OBSERVATORIO ASTRONOMICO, El Bosque, Cisterna, Santiago.

UNIVERSIDAD CATOLICA DE CHILE, Santiago.
Astronomy, biological and physical sciences, mathematics, medicine.

UNIVERSIDAD DE CHILE, Santiago.
Biological and physical sciences, mathematics, marine biology, medicine, seismology.

UNIVERSIDAD DE CONCEPCION, Concepcion.
Mathematics, medicine, physical sciences.

This information was received from the Embassy of Chile, Washington, D. C.; from the American Embassy, Santiago; and from UNESCO, Paris. February–April, 1948.

CHINA

ACADEMIA SINICA, Nanking.
Astronomy, geology, meteorology.

ACADEMIA SINICA, Shanghai.
Botany, chemistry, engineering, mathematics, medicine, physics, psychology, zoology.

AURORA UNIVERSITY, Shanghai.
Medicine, science and engineering; Le Musée Heude.

CATHOLIC UNIVERSITY OF PEIPING, Peiping.
Anthropology, biology, chemistry, physics, science.

CHINA GEOGRAPHICAL RESEARCH INSTITUTE, Nanking.

CHINESE ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE [formerly Science Society of China], 235 Shensi Road (South), Shanghai.

CHINESE CHEMICAL SOCIETY, c/o National Central University, Nanking.

CHINESE MEDICAL ASSOCIATION, 41 Tzeki Rd., Shanghai.

CHINESE PHYSICAL SOCIETY, c/o National Academy of Peiping, Peiping.

CHINESE PUBLIC HEALTH ASSOCIATION, 179 Pei Hsia Road, Nanking.

GEOLOGICAL SOCIETY OF CHINA, 942 Chukiang Road, Nanking.

LINGNAN UNIVERSITY, Canton.
Agriculture, biology, chemistry, medicine, physics, science and engineering.

NATIONAL ACADEMY OF PEIPING, Peiping.
Botany, chemistry, geology, physics, physiology, zoology.

NATIONAL ACADEMY OF PEIPING, Shanghai.
Materia medica, radium.

NATIONAL ACADEMY OF PEIPING, Wukang, Shensi.
Botanical survey of northwest China.

NATIONAL AMOY UNIVERSITY, Amoy.
Fisheries, oceanography, science and engineering.

NATIONAL ANWHEI UNIVERSITY, Anking.
Agriculture, science.

NATIONAL CENTRAL UNIVERSITY, Nanking.
General.

NATIONAL CHANGCHUN UNIVERSITY, Chungchun.
Agriculture, engineering, medicine.

NATIONAL CHEKIANG UNIVERSITY, Hangchow.
Agriculture, engineering, science.

NATIONAL CHIAO TUNG UNIVERSITY, Shanghai.
Engineering, science.

NATIONAL CHI NAN UNIVERSITY, Shanghai.
Science.

NATIONAL CHUNG CHEN UNIVERSITY, Nanchang, Kiangsi.
Agriculture, engineering, medicine, science.

NATIONAL CHUNGKING UNIVERSITY, Chungking.
Arts and science, engineering, medicine.

NATIONAL FUH TAN UNIVERSITY, Shanghai.
Agriculture, science.

NATIONAL HONAN UNIVERSITY, Kaifeng.
Agriculture, engineering, medicine, science.

NATIONAL HUNAN UNIVERSITY, Changsha.
Engineering, science.

NATIONAL KWANGSI UNIVERSITY, Kweilin.
Agriculture, science and engineering.

NATIONAL KWEICHOW UNIVERSITY, Kweiyang.
Agriculture, arts and science, engineering.

NATIONAL LANCHOW UNIVERSITY, Lanchow.
Arts and science, medicine, veterinary medicine.

NATIONAL NAKAI UNIVERSITY, Tientsin.
Science.

NATIONAL NORTHEASTERN UNIVERSITY, Mukden.
Agriculture, engineering, science.

NATIONAL NORTHWESTERN UNIVERSITY, Sian, Shensi.
Medicine, science.

NATIONAL PEI YANG UNIVERSITY, Tientsin.
Engineering, science.

NATIONAL PEKING UNIVERSITY, Peiping.
General.

NATIONAL SHANGHAI MEDICAL COLLEGE, Shanghai.
Biochemistry, medicine, pathology, pharmacology.

NATIONAL SHANSI UNIVERSITY, Taiyuan.
Engineering, medicine.

NATIONAL SHANTUNG UNIVERSITY, Tsingtao.
Agriculture, engineering, medicine, oceanography, science.

NATIONAL SUNYATSEN UNIVERSITY, Canton.
General.

NATIONAL SZECHWAN UNIVERSITY, Chengtu.
Agriculture, science and engineering.

NATIONAL TAIWAN UNIVERSITY, Taipei.
Agriculture, engineering, medicine, science.

NATIONAL TSING HUA UNIVERSITY, Peiping.
General.

NATIONAL TUNG CHI UNIVERSITY, Shanghai.
Engineering, medicine.

NATIONAL WUHAN UNIVERSITY, Wuchang.
General.

NATIONAL YIN SHIH UNIVERSITY, Kinghua, Chekiang.
Agriculture, arts and science, engineering.

NATIONAL YUNAN UNIVERSITY, Kunming.
Agriculture, engineering, medicine, science.

NATURAL SCIENCE SOCIETY OF CHINA, c/o National Central University, Nanking.

PEIPING UNION MEDICAL COLLEGE, Peiping.
Medicine, public health.

UNIVERSITY OF NANKING, Nanking.
Agriculture, science.

UNIVERSITY OF SHANGHAI, Shanghai.
Science.

YENCHING UNIVERSITY, Peiping.
Science.

The information for this selected list was received through the American Embassy at Nanking, China, from the office of Dr. Han Ch'ing-lien, Director of the Department of Cultural Relations of the Ministry of Education in Nanking. The very great number of scientific institutions in China makes it impossible to include all of them in this presentation: only the major institutions—most of the national universities and some of the established private universities and scientific associations — have been listed here. The special qualifications noted for them are generalizations based upon the colleges, institutes, or departments which Dr. Han's office has indicated are found at the respective institutions. In the cases of the largest universities, which possess most of the facilities and curricula offered by large universities the world over, the word *General* has been used to denote this fact.

Further information about the institutions listed here, or about the numerous smaller colleges and provincial universities, societies, and institutes throughout China which are not considered in this list, can be obtained from the helpful office of Dr. Han Ch'ing-lien in Nanking.

COLOMBIA

CENTRO NACIONAL DE INVESTIGACIONES DEL CAFE, Chinchiná, Caldas.
Coffee technology.

COLLEGIO DE SAN JOSE, Medellin, Antioquia.
General; Museum of Natural Sciences.

DEPARTAMENTO DE TIERRAS, Ministerio de la Economia Nacional, Bogotá.
Forestry and soil conservation.

DEPARTAMENTO TECNICO DE LA FEDERACION NACIONAL DE CAFETEROS, Bogotá.
Coffee technology.

DIVISIONES TECNICAS, Ministerio de Higiene, Bogotá.
Public health.

ESCUELA NACIONAL DE MINAS, Medellin, Antioquia.
Mining and associated sciences.

ESCUELA NORMAL SUPERIOR, Bogotá.
General.

ESTACION AGRICOLA EXPERIMENTAL DE ARMERO, Armero, Tolima.
Agricultural research.

ESTACION AGRICOLA EXPERIMENTAL DE PALMIRA, Palmira, Valle.
Agricultural research.

ESTACION AGRICOLA EXPERIMENTAL DE SEVILLA, Sevilla, Magdalena.
Agricultural research.

FACULTAD DE AGRONOMIA DE LA UNIVERSIDAD NACIONAL, Medellin, Antioquia.
Agronomy, agriculture.

GRANJA GANADERA DE MONTERIA, Monteria, Bolivar.
Veterinary parasitology.

INSTITUTO DE BIOLOGIA, Departamento Nacional de Agricultura, Instituto Ciencias Naturales de la Ciudad Universitaria, Apartado Postal 2535, Bogotá.
Botany, entomology, phytopathology.

INSTITUTO DE CIENCIAS NATURALES DE LA UNIVERSIDAD NACIONAL DE COLOMBIA, Ciudad Universitaria, Apartado Postal 2535, Bogotá.
Botany, entomology, ornithology.

INSTITUTO DE ESTUDIOS ESPECIALES "CARLOS FINLAY," Bogotá.
Medical entomology, virology.

INSTITUTO DE LA SALLE, Apartado 475, Bogotá.
Natural sciences.

INSTITUTO DE MALARIOLOGIA, Bogotá.
Malariology, parasitology.

INSTITUTO GEOFISICO DE LOS ANDES COLOMBIANOS, Apartado 270, Bogotá.
Geophysics, meteorology.

INSTITUTO NACIONAL DE HIGIENE "SAMPER MARTINEZ," Bogotá.
Chemotherapeutics, pharmacology, public health.

LABORATORIO CENTRAL DE INVESTIGACION DE LEPRA, Bogotá.
Leprosy.

LABORATORIO CUP (CESAR URIBE PIEDRAHITA), Bogotá.
Bacteriology, chemistry, parasitology, pharmacodynamics.

LABORATORIO QUIMICO NACIONAL DE ANALISIS E INVESTIGACION, Ministerio de Minas y Petróleos, Bogotá.
Geochemistry, geophysics.

OBSERVATORIO ASTRONOMICO NACIONAL, Bogotá.
Astronomy, meteorology.

UNIVERSIDAD DE ANTIOQUIA, Apartado 217, Medellin, Antioquia.
General.

UNIVERSIDAD NACIONAL DE COLOMBIA, Ciudad Universitaria, Bogotá.
General.

This list was selected from a *Directorio Científico Colombiano*, prepared by Dr. Enrique Perez Arbelaez at the direction of the Ministry of National Education, Colombia, and sent to us by the American Embassy, Bogotá, in January, 1948.

COSTA RICA

DEPARTAMENTO NACIONAL DE AGRICULTURA, San José.
Agriculture, botany.

INSTITUTO INTERNACIONAL DE CIENCIAS AGRICOLAS, Turrialba.
Agricultural research.

INSTITUTO NACIONAL GEOGRAFICO, San José.

UNIVERSIDAD DE COSTA RICA, San José.
General.

This information was received from the Embassy of Costa Rica, Washington, D. C.; from the American Embassy, San José; and from UNESCO, Paris. February–April, 1948.

ECUADOR

UNIVERSIDAD CATOLICA, Quito.

UNIVERSIDAD CENTRAL, Quito.

UNIVERSIDAD DE CUENCA, Cuenca.

UNIVERSIDAD DE GUAYAQUIL, Guayaquil.

UNIVERSIDAD DE LOJA, Loja.

This information was received from the Embassy of Ecuador, Washington, D. C., and from the American Embassy, Quito. January, 1948.

FIJI ISLANDS

AGRICULTURAL DEPARTMENT, Fiji Government, Suva. (Address the Director of Agriculture.)
["Office accommodation and library facilities... for one or two visiting scientists who are not concerned with laboratory studies..."]

MEDICAL DEPARTMENT, Fiji Government, Suva. (Address the Director of Medical Services.)

CENTRAL LEPER HOSPITAL, Makogai.

PATHOLOGICAL LABORATORY, Suva.
["Facilities... can readily be expanded to meet the requirements of special research projects. Visiting research workers would be welcome so far as limitations of space allow..."]

TUBERCULOSIS HOSPITAL, Tamavua.

This information was received from the Director of Agriculture and from the Director of Medical Services, Fiji Government, Suva, through the American Consulate, Suva; and from the British Consulate, Honolulu, T. H. February–March, 1948.

GUATEMALA

DIRECCION GENERAL DE AGRICULTURA, Departamentos de Sanidad Vegetal y Plantas Medicinales, Guatemala City.

INSTITUTO DE MINERIA E HIDROCARBUROS, Guatemala City.
Mining, soil science.

JARDIN BOTANICO, Paseo "La Reforma," Guatemala City.

OBSERVATORIO NACIONAL METEOROLOGICO, La Aurora.
Meteorology.

SOCIEDAD DE GEOGRAFIA E HISTORIA, Guatemala City.

This information was received from the Guatemalan Embassy, Washington, D. C., and from UNESCO, Paris. January–April, 1948.

HONDURAS

ASOCIACION MEDICA HONDURENA, Tegucigalpa.
Medical research.

ASOCIACION DE QUIMICA Y FARMACIA DE HONDURAS, Tegucigalpa.
Chemistry and pharmacology.

LANCETILLA EXPERIMENT STATION OF THE TELA RAILROAD COMPANY, La Lima.
USDA and United Fruit Company research in rubber and other plant crops.

SOCIEDAD DE ANTROPOLOGIA, Tegucigalpa.
Anthropology.

SOCIEDAD DE GEOGRAFIA E HISTORIA DE HONDURAS, Avenida Cervantes, Tegucigalpa.
Geography and history.

This information was received from the Honduran Ministry of Education, through the American Embassy, Tegucigalpa, and from UNESCO, Paris. January–April, 1948.

INDO-CHINA

ECOLE FRANCAISE D'EXTREME-ORIENT, 26 Boulevard Carreau, Hanoi.
Anthropology, archaeology, ethnology.

INSTITUT DE BIOLOGIE, Saigon.

INSTITUT OCEANOGRAPHIQUE DE NHATRANG, Nhatrang, Annam.

INSTITUT PASTEUR, in Dalat, Hanoi, Nhatrang, and Saigon.
Medicine, public health.

INSTITUT DE RECHERCHES AGRONOMIQUE DE SAIGON, 58 Rue du Docteur Angier, Saigon.

STATION D'ESSAI D'AGRICULTURE, Blas.

UNIVERSITE DE HANOI, 11 Boulevard Bobillot, Hanoi.
General.

UNIVERSITE DE SAIGON, Saigon.
Medicine, natural and physical sciences.

This information was received from the Embassy of France, Washington, D. C., and New York; from the French Consulate, Honolulu, T. H.; and from the American Consulate at Hanoi, Indo-China. February, 1948.

JAPAN

AGRICULTURAL EXPERIMENT STATION, Ministry of Agriculture and Forestry, Tokyo.

AGRICULTURAL RESEARCH INSTITUTE, Ofuna.

APPLIED SCIENCE RESEARCH INSTITUTE, Kyoto.

BREWING EXPERIMENT STATION, Ministry of Finance, Tokyo.

CANNING INSTITUTE OF JAPAN, Tokyo.

CHROMOSOMES RESEARCH INSTITUTE, Yamanishi-ken.

ELECTRONIC SCIENCE RESEARCH INSTITUTE, Osaka.

FERMENTATION RESEARCH INSTITUTE, Ministry of Commerce and Industry, Chiba.

FERTILIZER RESEARCH INSTITUTE, Tokyo.

FISHERIES EXPERIMENT STATION, Tokyo.

FOOD CHEMISTRY RESEARCH INSTITUTE, Osaka.

FOOD RESEARCH INSTITUTE, Ministry of Agriculture and Forestry, Tokyo.

FORESTRY EXPERIMENT STATION, Tokyo.

FUEL RESEARCH INSTITUTE, Ministry of Commerce and Industry, Saitama-ken.

FURUKAWA PHYSICAL AND CHEMICAL RESEARCH INSTITUTE, Tokyo.

GEOLOGICAL SURVEY, Tokyo.

GOVERNMENT CHEMICAL AND INDUSTRIAL RESEARCH LABORATORY, Ministry of Commerce and Industry, Tokyo.

GOVERNMENT HYGIENIC LABORATORY, Ministry of Welfare, Tokyo.

GOVERNMENT RESEARCH INSTITUTE FOR CERAMICS, Ministry of Commerce and Industry, Kyoto.

HAKODATE FISHERIES COLLEGE, Hakodate.

HATTORI FOUNDATION FOR BOTANICAL RESEARCH, Miyazaki-ken.

HIROSHIMA COLLEGE OF SCIENCE AND LITERATURE, Hiroshima.
General sciences, marine biological station, theoretical physics institute.

HITACHI CENTRAL LABORATORY, Tokyo.
Chemical, electrical, and mechanical technology.

HOKKAIDO FISHERIES EXPERIMENT STATION, Yoichi.

HOKKAIDO FORESTRY EXPERIMENT STATION, Sapporo.

HOKKAIDO INDUSTRIAL RESEARCH INSTITUTE, Sapporo.

HOKKAIDO UNIVERSITY, Sapporo.
Agricultural sciences, medicine, technological sciences; Akkeshi Marine Biological Station, Algological Research Laboratory, Institute of Low Temperature Research.

HORTICULTURAL EXPERIMENT STATION, Shizuoka-ken.

INDUSTRIAL MATERIALS RESEARCH LABORATORY, Fukuoka-ken.

IWATA INSTITUTE OF PLANT BIOCHEMISTRY, Tokyo.

KEIO UNIVERSITY, Tokyo.
Engineering, medicine, science.

KIHARA INSTITUTE FOR BIOLOGICAL RESEARCH, Kyoto.

KOBAYASHI BACTERIOLOGICAL LABORATORY, Fukushima-ken.

KOBAYASHI INSTITUTE OF PHYSICAL RESEARCH, Tokyo.

KYOTO MEDICAL COLLEGE, Kyoto.

KYOTO UNIVERSITY, Kyoto.
Agriculture, engineering, medicine, science; Beppu Volcanological Hot Springs Institute, Otsu Hydrobiological Station, Seto Marine Biological Station; Institutes of Chemical Research, Engineering Research, and Wood Research.

KYUSHU UNIVERSITY, Fukuoka.
Agriculture, engineering, medicine, science; Amakusa Laboratory for Marine Biology, Hikosan Biological Research Laboratory, Institute for Wood Research.

MEGURO RESEARCH INSTITUTE, Tokyo.
Biology, chemical technology.

NAGOYA RESEARCH INSTITUTE OF SCIENCE AND INDUSTRY, Nagoya.

NAGOYA UNIVERSITY, Nagoya.
Engineering, science; marine biological station.

NATIONAL RESEARCH COUNCIL, Tokyo.
Special committees for all fields of research.

NATURAL RESOURCES RESEARCH INSTITUTE, Tokyo.

NIHON UNIVERSITY, Tokyo.
Agriculture, engineering.

NOGUCHI RESEARCH INSTITUTE, Tokyo.
Medical microbiology.

NOHARA RESEARCH INSTITUTE, Nagoya.
Biochemistry, chemical technology.

OCEANOGRAPHIC CHEMISTRY INSTITUTE, Kyoto.

OHARA INSTITUTE FOR AGRICULTURAL RESEARCH, Okayama.

OSAKA INDUSTRIAL RESEARCH LABORATORY, Ministry of Commerce and Industry, Osaka.

OSAKA UNIVERSITY, Osaka.
Engineering, medicine, science; Institute of Scientific and Industrial Research.

PHYSICAL AND CHEMICAL RESEARCH INSTITUTE, Tokyo.

PHYSICAL INSTITUTE FOR RADIO WAVES, Tokyo.

SANKYO COMPANY, Tokyo.
Biochemistry, chemical technology.

SCIENTIFIC FISHERIES INSTITUTE, Hakodate.

SERICULTURE EXPERIMENT STATION, Tokyo.

TEA EXPERIMENT STATION, Shizuoka-ken.

TOHOKU UNIVERSITY, Sendai.
Engineering, medicine, science; Asamushi Marine Biological Station, Mukaiyama Observatory, Oceanochemistry Laboratory; Institutes of Agricultural Research, Glass, Metallurgy, and Scientific Measurements.

TOKUGAWA BIOLOGICAL INSTITUTE, Tokyo.

TOKYO COLLEGE OF AGRICULTURE AND FORESTRY, Tokyo.

TOKYO INSTITUTE OF TECHNOLOGY, Tokyo.

TOKYO UNIVERSITY, Tokyo.
Agriculture and fisheries, enginering, medicine, science; Botanical Garden, Misaki Marine Biological Station; Institutes of Astronomy, Earthquake Research, Radiation Chemistry, Physiographic Research, Science and Technology.

TOKYO UNIVERSITY OF LITERATURE AND SCIENCE, Tokyo.
Science; Shimoda Marine Biological Laboratory, Sugadaira High Land Biological Laboratory.

YAMASHINA ORNITHOLOGICAL INSTITUTE, Tokyo.

WASEDA UNIVERSITY, Tokyo.
Science and engineering.

This information was taken from Report No. 12 [*Index to Japanese Research and Development during Period July–December, 1946*, published April, 1948] of General Headquarters, Supreme Commander for the Allied Powers, Economic and Scientific Section. This *Index* "lists the detailed subjects of research projects pursued in Japan during the last half of 1946 in each field of science and technology, together with the names of the laboratories which did the work..." The selected list presented here by *Pacific Science* is considerably abridged, and shows only the major institutions in Japan—as best as can be judged from the SCAP *Index*—at which scientific research may be carried on. Many other institutions—like the prefectural experimental stations and colleges—are not listed here; and it is possible, according to the preface of the SCAP report, that some of the finest small laboratories in Japan have been omitted, unintentionally, because information about them was either unobtainable or because awareness of their quality was lost when their appraising was reduced to the statistics of the report.

Requests for information about institutions or facilities in Japan, and concerning their accessibility to visiting scientists, should be sent to General Headquarters, Supreme Commander for the Allied Powers, Economic and Scientific Section: attention Scientific and Technical Division, APO 500, c/o Postmaster, San Francisco, California.

KOREA

(South Korea Interim Government)

PUSAN FISHERIES COLLEGE, Pusan.

SEOUL NATIONAL UNIVERSITY, Seoul.
Arts and science, engineering, medicine, veterinary medicine.

SEOUL NATIONAL UNIVERSITY, Suwon.
Agriculture.

SEVERANCE MEDICAL COLLEGE, Seoul.
Medicine, nursing, public health.

This information was received from the Department of Education, South Korea Interim Government, USAMGIK, APO 235-2, c/o Postmaster, San Francisco, California. March, 1948.

MEXICO

INSTITUTO DE BIOLOGIA APPLICADA, Ignacio Mariscal 155, Mexico, D. F.

INSTITUTO DE CARDIOLOGIA, Calzada de la Piedad 300, Mexico, D. F.

INSTITUTO NACIONAL DE ANTROPOLOGIE HISTORIA, Córdoba 73, Mexico, D. F.

INSTITUTO PANAMERICANO DE GEOGRAFIA E HISTORIA, Observatoria 192, Tacubaya, D. F.

INSTITUTO DE SALUBRIDAD Y ENFERMEDADES TROPICALES, Plan de San Luis y Prolongación Carpio, Mexico, D. F.

OBSERVATORIO ASTRONOMICO NACIONAL, Tacubaya, D. F.

SOCIEDAD BOTANICA DE MEXICO, Morelos 61, Mexico, D. F.

SOCIEDAD DE ESTUDIOS ASTRONOMICOS Y GEOFISICOS, Av. Observatorio 192, Tacubaya, D. F.

SOCIEDAD MEXICANA DE ESTUDIOS SOBRE TUBERCULOSIS, Apartado Postal 2425, Mexico, D. F.

UNIVERSIDAD NACIONAL AUTONOMA:

INSTITUTO DE BIOLOGIA, Casa del Lago, Chapultepec, Mexico, D. F.

INSTITUTO DE FISICA, Tacuba 5, Mexico, D. F.

INSTITUTO DE GEOGRAFIA, Lic. Verdad No. 3, Mexico, D. F.

INSTITUTO DE GEOLOGIA, Cipres 176, Mexico, D. F.

INSTITUTO DE MATEMATICAS, Tacuba 5, Mexico, D. F.

INSTITUTO DE QUIMICA, Santa Cruz Atenco, Tacuba, D. F.

This information was received from the [Mexican] Commission for the Promotion and Coördination of Scientific Research, through the American Embassy, Mexico, D. F. February, 1948.

NETHERLANDS INDIES

ALGEMEEN PROEFSTATION DER ALGEMENE VERENIGING RUBBERPLANTERS SUMATRA OOSTKUST [CENTRAL EXPERIMENT STATION, GENERAL ASSOCIATION OF RUBBER PLANTERS OF THE EAST COAST OF SUMATRA], Medan, Sumatra.
Rubber research.

ALGEMEEN PROEFSTATION VOOR DEN LANDBOUW [GENERAL AGRICULTURAL EXPERIMENT STATION], Buitenzorg, Java, with a branch station at Makassar, Celebes.
Agricultural technology, botany, phytopathology, soils.

BOSBOUWPROEFSTATION [GOVERNMENT FOREST RESEARCH INSTITUTE], Buitenzorg, Java.

CENTRAAL BUREAU VOOR TECHNISCHE ONDERZOEKINGEN [CENTRAL TECHNOLOGICAL LABORATORIES], Karanganjar 55, Batavia, Java.

CENTRALE VERENIGING TOT BEHEER VAN PROEFSTATIONS VAN DE OVERJARIGE CULTURES IN NEDERLANDSCH-INDIE [ASSOCIATION OF COMBINED EXPERIMENT STATIONS FOR PERENNIAL CROPS IN THE NETHERLANDS INDIES], Central Office, Batavia, Java, with experiment stations at Buitenzorg, Djember, Klaten, and Malang, Java, and at Medan, Sumatra.
Agriculture and agronomy, especially of tobacco.

DIENST VAN DEN MIJNBOUW [DEPARTMENT OF MINES], Molenoliet Oost, Batavia, Java.
Head Office, and section for economic geology.

DIENST VAN DEN MIJNBOUW [DEPARTMENT OF MINES], Wilhelmina Boulevard 7, Bandoeng, Java.
Chemistry, engineering geology, geological exploration, geological museum, paleontology, and volcanology.

EIJKMAN INSTITUTE [Central Laboratory of the Public Health Service of the Netherlands Indies], Oranje Boulevard 69, Batavia, Java.
Medicine, nutrition, public health.

GEWESTELIJK LABORATORIUM VAN DEN DIENST DER VOLKSGEZONDHEID [REGIONAL LABORATORY OF THE PUBLIC HEALTH SERVICE], Makassar, Celebes.

INSTITUUT VOOR LEPRA ONDERZOEK [LEPROSY RESEARCH INSTITUTE], Bandoeng, Java.

INSTITUUT PASTEUR, Pasteursweg, Bandoeng, Java.

INSTITUUT VOOR DE ZEEVISSERIJ [FISHERIES RESEARCH INSTITUTE], Pasar Ikan, Batavia, Java.

KON. BATAVIAASCH GENOOTSCHAP VAN KUNSTEN EN WETENSCHAPPEN [ROYAL BATAVIAN SOCIETY OF ARTS AND SCIENCES], Koningsplein West 12, Batavia, Java.

KON. MAGNETISCH EN METEOROLOGISCH OBSERVATORIUM [ROYAL METEOROLOGICAL OBSERVATORY], Engelsche Kirkweg 3, Batavia, Java.

KON. NATUURKUNDIGE VERENIGING IN NEDERLANDSCH-INDIE [ROYAL SCIENCE SOCIETY], Koningsplein Zuid 11, Batavia, Java.

LABORATORIUM VOOR DE BINNENVISSERIJ [LABORATORY FOR INLAND FISHERIES], Buitenzorg, Java.

LABORATORIUM VOOR SCHEIKUNDIG ONDERZOEK [LABORATORY FOR CHEMICAL RESEARCH], Buitenzorg, Java.

LABORATORIUM VOOR TECHNISCHE HYGIENE [LABORATORY FOR TECHNICAL HYGIENE], Schoolweg, Bandoeng, Java.

S LANDS PLANTENTUIN [GOVERNMENT BOTANICAL GARDENS], Batavia, Java.
Laboratorium voor het Onderzoek der Zee (Laboratory for Marine Biology).

S LANDS PLANTENTUIN [GOVERNMENT BOTANICAL GARDENS], Buitenzorg, Java.
Herbarium en Museum voor systematische Botanie (Herbarium and Museum for systematic botany), Treub Laboratorium (Visitors' Laboratory), Zoölogisch Museum (Zoological Museum).

S LANDS PLANTENTUIN [GOVERNMENT BOTANICAL GARDENS], Tjibodas, Java.
Bergtuin Tjibodas (Tjibodas Mountain Garden).

MILITAIR HYGIENISCH INSTITUUT [MILITARY HYGIENE INSTITUTE], Hospitalsweg 24, Batavia, Java.

NEDERLANDS INDISCH INSTITUUT VOOR RUBBERONDERZOEK [NETHERLANDS INDIES INSTITUTE FOR RUBBER RESEARCH], Buitenzorg, Java.

NEDERLANDS INDISCH STERRENKUNDIGE VERENIGING [NETHERLANDS INDIES ASTRONOMICAL SOCIETY] Oude Hospital weg 14, Bandoeng, and Bosscha Sterrenwacht, Lembang, Java.

PROEFSTATION VAN DE JAVA-SUIKERINDUSTRIE [EXPERIMENTAL STATION FOR THE JAVA SUGAR INDUSTRY], Passoeroean, Java.

TOPOGRAFISCHE DIENST [TOPOGRAPHICAL SURVEY], Goenoeng Sahari 89, Batavia, Java.

UNIVERSITEIT VAN INDONESIE [UNIVERSITY OF INDONESIA], Bandoeng, Java.
Technical sciences and mathematics.

UNIVERSITEIT VAN INDONESIE [UNIVERSITY OF INDONESIA], Batavia, Java.
Medicine.
UNIVERSITEIT VAN INDONESIE [UNIVERSITY OF INDONESIA], Buitenzorg, Java.
Agricultural sciences, veterinary sciences.
VEEARTSENIJKUNDIG INSTITUUT [VETERINARY RESEARCH INSTITUTE], Buitenzorg, Java.
WATERLOOPKUNDIG LABORATORIUM [HYDRODYNAMICS LABORATORY], Hogeschoolweg, Bandoeng, Java.

This information was received from Organisatie Natuurwetenschappelijk Onderzoek i. o. (Organization for Scientific Research in the Netherlands Indies, prep. comm.), Koningsplein Zuid 11, Batavia, Java; from the book, *Science and Scientists in the Netherlands Indies,* edited by Pieter Honig and Frans Verdoorn, and published in 1945 in New York City by the Board for the Netherlands Indies, Surinam, and Curaçao; and from the American Consulate General, Batavia, Java. March, 1948.

NEW CALEDONIA

INSTITUT FRANCAIS D'OCEANIE, Noumea, New Caledonia.
Agricultural entomology, ethnology, geology, marine biology, phytopathology, physical oceanography, and others to be added.

["The purpose of the Institute is . . . research of a scientific nature in the French regions of the Pacific, and a thorough collaboration in all research with foreign scientists to corroborate observations of general interest. The first program was formed at the suggestion of the South Pacific Commission."—From a letter from the Director of the Institute.]

This information was received from the Director of the Institute, through the American Consulate at Noumea, New Caledonia. February, 1948.

NEW ZEALAND

AGRICULTURE DEPARTMENT, Head Office, Dominion Farmers' Institute Building, Wellington, C. 1. (Communications should be addressed to the Director-General of Agriculture.)
RUAKURA ANIMAL RESEARCH STATION, Ruakura, South Auckland Province.
RUKUHIA SOIL FERTILITY RESEARCH STATION, Rukuhia, South Auckland Province.
SEED TESTING STATION, Palmerston North.
WALLACEVILLE ANIMAL RESEARCH STATION, Wallaceville, Wellington.
AUCKLAND MUSEUM, Auckland.
{Facilities for visiting scientists are not available at present.}
CANTERBURY MUSEUM, Christchurch.
Biology, ethnology.
CARTER OBSERVATORY, Wellington.
CAWTHRON INSTITUTE, Nelson.
Entomology, plant problems, soil.
DOMINION MUSEUM, Wellington.
Natural sciences.
HAWKES BAY MUSEUM, Napier.
Maori ethnology; Russell Duncan Library of exploration in New Zealand, Pacific, and Antarctic.
LEATHER AND SHOE RESEARCH ASSOCIATION, 111 Sydney Street, Wellington.
MARINE DEPARTMENT, Head Office, T. & G. Building, Lambton Quay, Wellington.
MARINE DEPARTMENT, Fishery Research Laboratory, Clark's Building, Wingfield Street, Wellington, N. 1.
NEW ZEALAND FERTILISER MANUFACTURERS' RESEARCH ASSOCIATION, (INC.), P. O. Box 2080, Auckland.
NEW ZEALAND POTTERY AND CERAMICS RESEARCH ASSOCIATION, (INC.), 111 Sydney Street, Wellington.
NEW ZEALAND WOOLEN MILLS RESEARCH ASSOCIATION, (INC.), c/o Prof. E. G. Soper, Chemistry Department, University of Otago, Dunedin.
OTAGO MUSEUM, Dunedin.
Ethnology of New Zealand and of Pacific Islands, especially of New Hebrides.
SCIENTIFIC AND INDUSTRIAL RESEARCH DEPARTMENT [Dominion Government]:
AGRONOMY DIVISION, Private Bag, Christchurch.
APIA OBSERVATORY, Apia, Western Samoa.
Research on terrestrial magnetism, tidal observations, and seismology.

ATOMIC PHYSICS SECTION, 37 Majoribanks Street, Wellington.

AUCKLAND INDUSTRIAL DEVELOPMENT LABORATORIES, P. O. Box 2225, Auckland.

BIOMETRICS SECTION, 37 Majoribanks Street, Wellington.

BOTANY DIVISION, 8 The Terrace, Wellington.

DEFENSE DEVELOPMENT SECTION, P. O. Box 1152, Christchurch.

DOMINION LABORATORIES:
Durham Street West, Auckland.
P. O. Box 1290, Christchurch.
P. O. Box 562, Dunedin.
111 Sydney Street, Wellington.

DOMINION OBSERVATORY, Kelburn, Wellington.

DOMINION PHYSICAL LABORATORY, Gracefield Road, Lower Hutt.

ECONOMIC SURVEYS, 117 Sydney Street, Wellington.

ENTOMOLOGY DIVISION, Cawthron Institute, Nelson.

FATS RESEARCH LABORATORY, Sydney Street, Wellington.

FLAX RESEARCH STATION, Foxton.

GEOLOGICAL SURVEY, Head Office, 156 The Terrace, Wellington.

GEOLOGICAL SURVEY, Volcanological Laboratory, Rotorua.

GRASSLANDS DIVISION, P. O. Box 16, Palmerston North.

HEAD OFFICE, 117 Sydney Street, Wellington. (Address the Secretary.)

INDUSTRIAL PSYCHOLOGY DIVISION, Bowen Street, Wellington.

INFORMATION BUREAU, 117 Sydney Street, Wellington.

IONOSPHERE SECTION, Christchurch.

MAGNETIC OBSERVATORY, Hagley Park, Christchurch.

PLANT CHEMISTRY LABORATORY, P. O. Box 16, Palmerston North.

PLANT DISEASES DIVISION, Private Bag, Auckland.

SOIL BUREAU, 54 Molesworth Street, Wellington.

WILD LIFE SECTION, 117 Sydney Street, Wellington.

STATE FOREST SERVICE, 23 Fitzherbert Terrace, Wellington, N. 1. (Address the Director.)

UNIVERSITY OF NEW ZEALAND, Bowen Street, Wellington. (Address the Registrar.) [The "governing body" of the Universities and Colleges of the Dominion.]

AUCKLAND UNIVERSITY COLLEGE, Auckland. (Address the Registrar.)
Architecture, botany, chemistry, geology, marine biology, physics.

CANTERBURY AGRICULTURAL COLLEGE, Lincoln, Canterbury. (Address the Registrar.)
General.

CANTERBURY UNIVERSITY COLLEGE, Christchurch. (Address the Rector.)
General; mountain botanical station.

MASSEY AGRICULTURAL COLLEGE, Palmerston North. (Address the Principal.)
Agricultural research, dairy research, veterinary sciences.

UNIVERSITY OF OTAGO, Dunedin. (Address the Registrar.)
Bacteriology and public health, dentistry, home science, medicine, mines and metallurgy.

VICTORIA UNIVERSITY COLLEGE, Wellington. (Address the Registrar.)
General.

This information was received from the Information Bureau of the Department of Scientific and Industrial Research of the Dominion Government of New Zealand, through the Legation of New Zealand, Washington, D. C., and the American Legation, Wellington, N. Z.; from the Art Galleries and Museums Association of New Zealand, Wellington; from the Registrars, Principals, and Rectors of the several universities and colleges making up the University of New Zealand; and from UNESCO, Paris. March–May 1, 1948.

NICARAGUA

COLLEGIO CENTRO AMERICA, Granada.

INSTITUTO PEDAGOGICO DE VARONES, Managua, D. N.

This information was received from the American Embassy, Managua, D. N., Nicaragua. March, 1948.

PANAMA

GORGAS MEMORIAL LABORATORY, Apartado 1252, Panamá. (Address the Director.)
Medical entomology.

INSTITUTO NACIONAL DE AGRICULTURA, Divisa. (Address the Director.)
Agricultural research.

MUSEO NACIONAL DE PANAMA, Apartado 662, Panamá. (Address the Director.)
Archaeology, entomology.

This information was received from the American Embassy, Panamá, Republic of Panama. January, 1948.

PERU

ESCUELA SUPERIOR DE CIENCIAS PEDAGOGICAS, Avenida Grau 429, Lima.

ESTACION EXPERIMENTAL AGRICOLA DEL NORTE, Lambayeque.

ESTACION EXPERIMENTAL AGRICOLA DE LA MOLINA (INSTITUTO DE ALTOS ESTUDIOS), Lima.

FACULTAD DE CIENCIAS MEDICAS, Lima.

INSTITUTO DE GENETICA DEL ALGODON DE LA SOCIEDAD NACIONAL AGRARIA, Apartado 350, Lima.

This information was received from the Peruvian Embassy, Washington, D. C., and from UNESCO, Paris. January–April, 1948.

THE PHILIPPINES

BUREAU OF ANIMAL INDUSTRY, Manila.
BUREAU OF FISHERIES, Manila.
BUREAU OF FORESTRY, Manila.
BUREAU OF HEALTH, Manila.
BUREAU OF HOSPITALS, Manila.
BUREAU OF MINES, Manila.
BUREAU OF PLANT INDUSTRY, Manila.
INSTITUTE OF SCIENCE (formerly Bureau of Science), Manila.
NATIONAL MUSEUM, Manila.
PHILIPPINE GENERAL HOSPITAL, Manila.
UNIVERSITY OF THE PHILIPPINES, Manila.
WEATHER BUREAU, Manila.

This information was received from the Institute of Science, Manila, through the Philippine Consulate-General, Honolulu, T. H. February, 1948.

EL SALVADOR

CENTRO NACIONAL DE AGRONOMIA, Santa Tecla, Depto. La Libertad.
Agricultural research.

DIRECCION GENERAL DE SANIDAD, Calle Arce No. 87, San Salvador.
Public health and tropical diseases.

UNIVERSIDAD AUTONOMA DE EL SALVADOR, Ave. Cuscatlán y 2a. Calle Poniente, San Salvador.
Architecture and engineering, chemistry, dentistry, medicine, pharmacy.

This information was received from the Embassy of El Salvador, Washington, D. C., and from the American Embassy, San Salvador, El Salvador. January, 1948.

SIAM

THE CHULALONGKON UNIVERSITY, Bangkok.
General.

DEPARTMENT OF AGRICULTURE EXPERIMENT STATION, Bangkok.
Agricultural research.

LEPROSY CONTROL DEPARTMENT AND LEPER HOSPITAL, Department of Public Health, Bangkok.

PASTEUR INSTITUTE, Saladaeng, Bangkok.
Bacteriology, serology.

This information was received from the Royal Siamese Embassy, Washington, D. C., and from the American Embassy, Bangkok, Siam. February, 1948.

SIBERIA (U.S.S.R.)

No information available.

UNITED STATES

[It would be impossible, of course, to name every institution in the United States which has some concern with science in the Pacific. In this list only the major institutions in the Pacific states of the United States and in the territories of Alaska and Hawaii have been noted. Information concerning the institutions in Hawaii was taken principally from *Pacific Science* 1: 119–126, 1947, and for Alaska and the Pacific states from the catalogues of the several institutions included in the list.]

ALASKA

UNIVERSITY OF ALASKA, Fairbanks.
General, especially archaeology, geophysics.

CALIFORNIA

CALIFORNIA ACADEMY OF SCIENCE, San Francisco.
General.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Pasadena.
General; Arms Laboratory of Geological Sciences, Bridge Laboratory of Physics, Chemical Engineering Laboratory, Experiment Station, Gates and Crellin Laboratory of Chemistry, High-Potential Research Laboratory, Hydrodynamics Laboratory, Kellogg Laboratory of Radiation, Kerckhoff Laboratories of the Biological Sciences, Kerckhoff Marine Biological Laboratory (at Corona del Mar), Mudd Laboratory of the Geological Sciences, Robinson Laboratory of Astrophysics, Seismological Research Laboratory, and others.

COLLEGE OF THE PACIFIC, Stockton.
General; Pacific Marine Station of Biological Sciences at Dillon Beach.

POMONA COLLEGE, Claremont.
General; Marine Laboratory at Laguna Beach.

STANFORD UNIVERSITY, Palo Alto.
General; Hopkins Marine Station at Pacific Grove; Natural History Museum.

STATE OF CALIFORNIA, DIVISION OF FISH AND GAME, FISHERIES LABORATORY, Terminal Island, San Pedro.

UNIVERSITY OF SOUTHERN CALIFORNIA, 3551 University Avenue, Los Angeles 7.
General; Allan Hancock Foundation for Biological Sciences.

UNIVERSITY OF CALIFORNIA.
["The University of California is composed of academic colleges, professional schools, divisions, departments of instruction, museums, libraries, research institutes, bureaus, and foundations, and the University of California Press, situated on eight different campuses throughout the State, namely: Berkeley, Los Angeles, San Francisco, Davis, Riverside, Mount Hamilton, La Jolla, and Santa Barbara."—*Catalogue*, University of California, 1948.]

I. AT BERKELEY.
General; Anthropological Museum, California Museum of Vertebrate Zoology, Crocker Radiation Laboratory, Institute of Experimental Biology, Museum of Paleontology.

II. AT LOS ANGELES.
General; Medical Department.

III. AT SAN FRANCISCO.
Dentistry, medicine, nursing, public health; Hooper Foundation for Medical Research.

IV. AT DAVIS.
Agricultural research, veterinary sciences.

V. AT RIVERSIDE.
Agricultural research; Citrus Experiment Station.

VI. AT MOUNT HAMILTON.
Lick Observatory.

VII. AT LA JOLLA.
Scripps Institution of Oceanography.

U. S. FISH AND WILDLIFE SERVICE, Stanford University, Palo Alto.
South Pacific Investigations in Ichthyology.

HAWAII

BERNICE P. BISHOP MUSEUM, Honolulu 35.
Collection, preservation, and study of Hawaiian and Pacific material in ethnology and the natural sciences; departments and collections of botany, entomology, malacology (both terrestrial and marine), marine zoology; large collections in ichthyology, ornithology, and geology. Library, chiefly on Pacific ethnology and natural history.

CALIFORNIA PACKING CORPORATION, P. O. Box 149, Honolulu 10.
Canning operations.

HAWAII MARINE LABORATORY, Coconut Island, Oahu. [Communications should be addressed to the Department of Zoology and Entomology, University of Hawaii, Honolulu 10.]
Marine biology, oceanography.

HAWAII NATIONAL PARK, U. S. Department of the Interior, National Park Service, Hawaii National Park, Hawaii.
Natural history.

HAWAIIAN PINEAPPLE COMPANY, LIMITED, Honolulu 1.
Research in growing and processing of pineapples and other subtropical crops.

HAWAIIAN SUGAR PLANTERS' ASSOCIATION EXPERIMENT STATION, 1527 Keeaumoku Street, Honolulu 4.
Agriculture, botany and forestry, chemistry, climatology, entomology, genetics, geology, pathology, physiology and biochemistry, sugar technology.

HAWAIIAN TUNA PACKERS, LIMITED, P. O. Box 238, Honolulu.
Research in oceanic fisheries methods.

HAWAIIAN VOLCANO OBSERVATORY (a branch of the U. S. Geological Survey collaborating with the Hawaiian Volcano Research Association and the University of Hawaii), Hawaii National Park, Hawaii.
Measurements and observations on active volcanoes; research in the chemistry and physics of volcanoes.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION, c/o University of Hawaii, Honolulu 10.
Research in physical processes of Hawaiian volcanoes. (The Directors will receive applications at any time from research investigators holding doctorate degrees who desire to pursue specialized studies in Hawaii in seismology, volcanology, and volcanological oceanography. Persons of advanced grade holding fellowships from other institutions may be assisted in travel expenses and may be provided with apparatus or use of facilities. Inquiries should be addressed to Dr. T. A. Jaggar, Scientific Director, at University of Hawaii, Honolulu 10, Hawaii.)

HONOLULU BOARD OF WATER SUPPLY, P. O. Box 3410, Honolulu 1.
Bacteriology, chemistry, geology.

LIBBY, MCNEILL AND LIBBY, P. O. Box 1140, Honolulu 7.
Pineapple production and processing.

PACIFIC CHEMICAL AND FERTILIZER COMPANY, P. O. Box 48, Honolulu 10.
Agricultural chemistry.

PINEAPPLE RESEARCH INSTITUTE OF HAWAII, P. O. Box 3166, Honolulu 2.
Agricultural engineering, chemistry, entomology, genetics, meteorology, plant pathology, plant physiology, as related to production of pineapple plants and fruit.

TERRITORIAL BOARD OF AGRICULTURE AND FORESTRY, P. O. Box 3319, Honolulu 1.
Animal industry, entomology, fish and game, forestry.

TERRITORIAL BOARD OF HEALTH, Honolulu.
Public health laboratories on major islands of Hawaiian group.

U. S. BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, University of Hawaii Campus, P. O. Box 340, Honolulu 9.
Fruitfly investigations.

U. S. COAST AND GEODETIC SURVEY, Pacific District Headquarters, 244 Federal Office Building, Honolulu.

U. S. GEOLOGICAL SURVEY, Division of Surface Waters, 225 Federal Office Building, Honolulu.

U. S. GEOLOGICAL SURVEY, Ground Water Division, 333 Federal Office Building, Honolulu.

U. S. GEOLOGICAL SURVEY, Hawaiian Volcano Observatory. See HAWAIIAN VOLCANO OBSERVATORY.

U. S. WEATHER BUREAU, Federal Office Building, Honolulu.

UNIVERSITY OF HAWAII, P. O. Box 18, Honolulu 10.
General; Library; Marine Biological Laboratory; cooperative associations with U. S. Bureau of Entomology and Plant Quarantine, the Pineapple Research Institute, the Hawaiian Sugar Planters' Association Experiment Station, the University of Hawaii Agricultural Experiment Station, the B. P. Bishop Museum, and many other private and governmental agencies in Hawaii.

UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION, P. O. Box 18, Honolulu 10.
Agricultural chemistry, agricultural engineering, agronomy, animal husbandry, entomology, horticulture, nutrition, parasitology, plant pathology, plant physiology, poultry husbandry, vegetable crops.

OREGON

OREGON STATE COLLEGE, Corvallis.
General.

UNIVERSITY OF OREGON, Eugene.
General; Condon Museum of Geology, Museum of Natural History, Oregon State Museum of Anthropology.

UNIVERSITY OF OREGON, Portland.
Medicine, public health.

WASHINGTON

MUSEUM OF THE STATE OF WASHINGTON, Seattle.
General, especially anthropology and vertebrate zoology.

STATE COLLEGE OF WASHINGTON, Pullman.
General.

UNIVERSITY OF WASHINGTON, Seattle 5.
General; Oceanographic Laboratories at Seattle and Friday Harbor.

U. S. FISH AND WILDLIFE SERVICE, Mountlake Laboratory, Seattle.

Juvenile *Euthynnus lineatus* and *Auxis thazard* from the Pacific Ocean off Central America

MILNER B. SCHAEFER AND JOHN C. MARR[1]

IN A PREVIOUS PAPER (Schaefer and Marr, in press), juvenile stages of two commercially important tunas, *Neothunnus macropterus* (Temminck and Schlegel) and *Katsuwonus pelamis* (Linnaeus) were described. They were taken, with dip nets at night, under flood lights, in the oceanic waters of the Pacific off Costa Rica and northern Panama. At some of the same stations where these were taken, and at others, juveniles of two other species of scombroid fishes which have been identified as *Euthynnus lineatus* Kishinouye, the black skipjack, and *Auxis thazard* (Lacépède), the frigate mackerel, were captured by the same means. Neither of these is utilized by the American commercial fishery in the Pacific. The black skipjack of the Asiatic side of the Pacific, *E. yaito* Kishinouye, however, is of considerable commercial importance to the Japanese fishery and it may be expected that *E. lineatus* will eventually be similarly exploited. Commercial catches of frigate mackerel in the middle Atlantic states averaged slightly over 100 tons in 1942–44 (Fiedler, 1945; Anderson and Power, 1946, 1947).

Euthynnus lineatus Kishinouye 1920

Adults of this species are occasionally captured in Central American waters incidentally to the tuna fishery. Four specimens were examined by us in the early spring of 1947. Two of these were captured in a bait-net in the Gulf of Nicoya, Costa Rica, on February 22; these fish, one male and one female, had gonads in a very advanced stage of maturity. A female with running-ripe eggs was taken on a trolled feather jig off Quepos Point, Costa Rica, on April 4. A ripe male was taken in a purse seine haul off Cape Blanco, Costa Rica, on April 29. It is thus apparent that this species spawns in Central American waters during the early spring. The capture of juveniles further confirms this.

Juveniles were taken at the following stations on the dates indicated: 08° 20′ N., 84° 10′ W., March 18, 1947; 8 specimens, 48 to 86 mm. total length. 09° 20′ N., 85° 20′ W., March 19, 1947; 10 specimens, 29 to 56 mm. total length. 09° 10′ N., 85° 20′ W., March 20, 1947; 1 specimen, 61 mm. total length. (All total lengths in this paper are from tip of snout to tip of shortest median caudal ray.)

In Figures 1 and 2 representative specimens of these juveniles are depicted. They are relatively less deep bodied than the juveniles of *Neothunnus* of the same sizes, being similar in this regard to *Katsuwonus*, from which, however, they may easily be distinguished by the pigmentation of the first dorsal fin. The entire first dorsal is heavily pigmented in *Euthynnus* of all sizes collected, while in *Katsuwonus*, up to 44 mm. at least, there is only a light pigmentation of the anterior margin and of the distal edge of the fin.

The second dorsal fin remains completely unpigmented in fish up to about 45 mm. total length, at which size the fin begins to show some pigment at the bases of the rays. In our largest specimen, 86 mm. total length, the second dorsal is fairly dark about half way to the tips of the rays, the distal half remaining unpigmented. The pigmentation of the head and body is similar to that of *Katsuwonus* at

[1] South Pacific Investigations, U. S. Fish and Wildlife Service. Published by permission of the Director of the U. S. Fish and Wildlife Service. Manuscript received March 25, 1948.

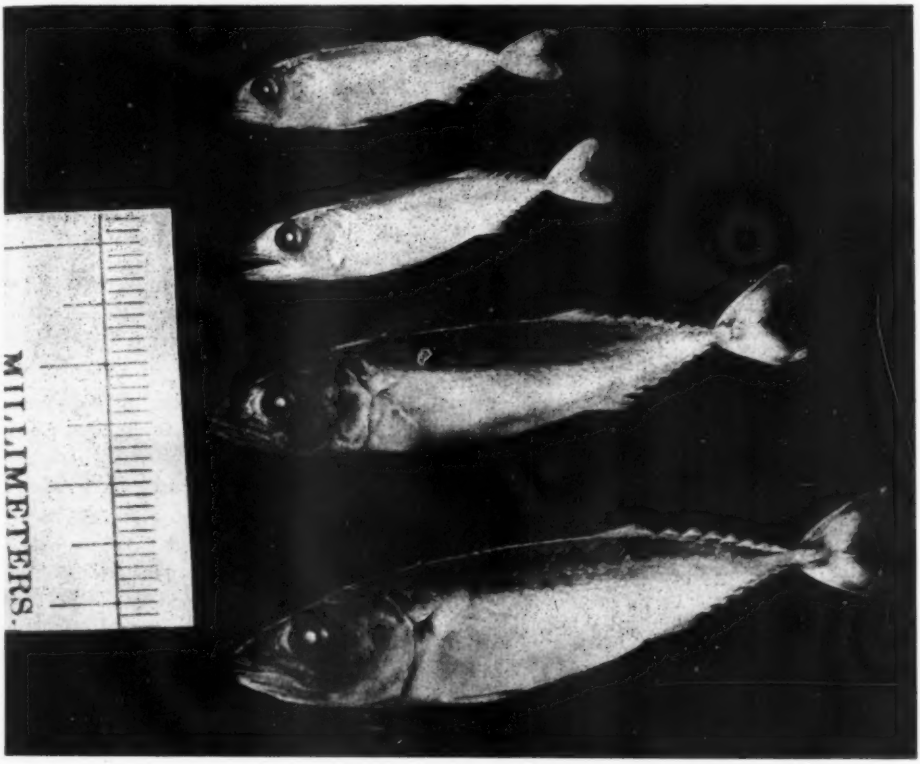

FIG. 1. Photograph of juvenile *Euthynnus lineatus* Kishinouye.

the smaller sizes, but the snout and anterior part of the head is rather more extensively pigmented in the smaller *Euthynnus* of these collections than in either *Katsuwonus* or *Neothunnus* of similar sizes. On the smaller of our specimens of *Euthynnus* the lateral pigmentation does not extend far below the mid-line, but there is a conspicuous series of black spots along the bases of the anal fin and following finlets. As the fish increase in size the pigmentation extends further down the sides, particularly posteriorly, until at about 45 mm. the pigmentation at the level of the anal fin extends the entire depth of the fish, although shading off ventrally. By the time the fish has reached 55 mm. the entire head is rather dark, the body is almost black dorsally, shading off gradually to a white belly. In some specimens of about 45 mm. to 60 mm. the pigment on the upper sides is concentrated to form 8 or 9 extremely faint vertical bars. In the 86 mm. specimen these are not visible. The peritoneum bears numerous large dark spots dorsally which are visible through the body wall in small specimens. The caudal fin begins to exhibit some pigmentation in fishes of about 50 mm. total length.

In addition to the examination of specimens preserved in alcohol, two specimens of 54 mm. and 56 mm. were prepared for study of bony parts by staining with alizarin and clearing, after the method of Hollister (1934). The pectoral fin in the two stained specimens has 29 rays and 27 rays, respectively. These rays

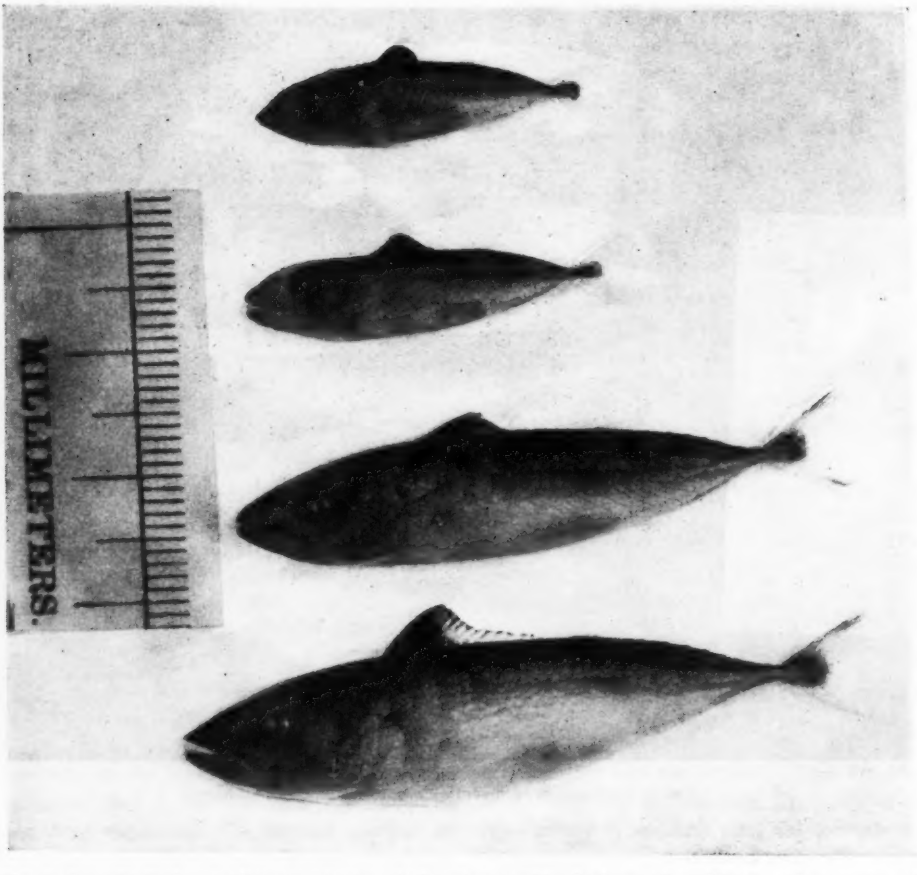

FIG. 2. Juvenile *Euthynnus lineatus;* photographed against a white background to illustrate pigmentation of dorsal fin.

cannot be counted accurately in unstained individuals because of the small size of the most inferior rays. The dorsal fin has 15 spines in six specimens examined and 14 in a seventh, the first or second anterior spines, which are of nearly equal length, being the longest and the remaining spines decreasing in length rapidly and successively. The first dorsal reaches almost to the insertion of the second. The second dorsal fin rays, counted in 5 specimens, are 12 in number, and there are in each case 8 dorsal finlets. The anal fin has 11 or 12 rays, and there are 7 anal finlets. The rays of the second dorsal and anal are difficult to count except in stained material because of the shortness of the first one or two rays. The finlets are connected to each other and to the fin by a thin membrane which extends less and less far toward the tips of the finlets as the fish grow until in the largest specimen of 86 mm. it is only a vestige between the bases of the finlets.

The gill rakers of our smallest specimens are very tiny projections on the gill arches and are difficult to count accurately. On such a specimen, of 32 mm. total length, they were counted on the first gill arch as 7 + 20. As the

fish increase in size the gill rakers not only increase rapidly in length, but their number apparently increases. Counts of rakers on the first arch on specimens of various sizes are as follows:

48 mm.	8 + 25
52 mm.	9 + 25
61 mm.	10 + 26
86 mm.	11 + 27

The vertebrae, counting the urostyle, are 19 + 18 in one stained specimen and 20 + 17 in the other. They bear large inferior foramina on the last three or four precaudal vertebrae and on the first nine or ten caudal vertebrae. The haemal canal is very large, being broader than the body of the vertebrae beneath the precaudal and anterior caudal vertebrae. The lateral processes of the posterior caudal vertebrae are well developed in both specimens; there are no lateral processes on the anterior precaudal vertebrae. The first complete haemal arch was found to be on the 15th vertebra by dissection of the 56 mm. specimen.

Specimens of all sizes in our collection have about 20 to 30 conical, inwardly curved teeth on each side of each jaw. The palatines each bear a row of eight to ten rather large conical teeth. The vomer bears four or five rather small teeth which may be easily overlooked.

Our very smallest specimens, of about 30 mm., have visible the remnants of three spines at the lower posterior angle of the preopercle. In larger specimens the growth of the bone has completely obliterated these. Smaller specimens than those in our collection may be presumed, by analogy with *Neothunnus,* to have more prominent and perhaps more numerous preopercular spines.

The intestine of these specimens, as is characteristic of the Katsuwonidae, is relatively straight and is not folded. It runs back along the right inferior portion of the stomach. The liver is in three lobes, the right lobe being very much longer than the other two. In seven specimens examined, the right lobe of the liver extended posteriorly three-fourths or more of the length of the body cavity.

That these specimens belong to either the genus *Euthynnus* or *Katsuwonus* is indicated by the morphology of the vertebral column. The well-developed inferior foramina on some precaudal as well as caudal vertebrae, forming with the very large haemal arches the so-called "trellis," is characteristic of these genera (Starks, 1910; Kishinouye, 1923).

These specimens have several characters agreeing with *Euthynnus* but not *Katsuwonus.* The very great elongation of the right lobe of the liver is definitive. In *Katsuwonus,* both in adults described by Kishinouye (1923: 363, 450, and 453, Fig. N) and by Godsil and Byers (1944: 11, 30), and in juveniles described by Schaefer and Marr (in press), the right lobe, although much larger than the other two, is not nearly as large as that of these specimens, which corresponds to Kishinouye's description of the liver of *Euthynnus.* The first closed haemal arch of *Katsuwonus* occurs on the 12th vertebra according to both Kishinouye and Godsil and Byers, whereas Kishinouye states that *Euthynnus* has the first complete haemal arch further back, on the 16th vertebra. The low vertebral count of our specimens is also definitive, although this was a matter of some concern at first because it does not agree with the literature. Kishinouye (1923: 338, 452) found that *Euthynnus* has 39 vertebrae counting the urostyle, probably based on *E. yaito* alone. He described *E. lineatus* from a single specimen from Manzanillo, Mexico, but probably did not dissect the fish to count the vertebrae. (Kishinouye: in the *Suisan Gakkwai Ho,* III, 113, 1920. We have been unable to examine this reference and our information is from Kishinouye, 1923.) He differentiates this species from *E. yaito* on the coloration and the relative size of the head. In his discussions he assumes all species of *Euthynnus* to have 39 vertebrae. This matter was cleared up through the kind cooperation of C. R. Clothier of the

California State Fisheries Laboratory, who has examined the skeletons of four adults identified from Kishinouye's description as *E. lineatus*. He has sent us the following data regarding these specimens, the first three of which were from tuna-clipper landings from unknown points somewhere south of the Mexican border, and the fourth of which was captured off Espiritu Santu Island in the Gulf of California:

Specimen number	1	2	3	4
Vertebra bearing 1st haemal arch	—	16	15	16
Total vertebrae (including urostyle)	37	39	37	37
Abdominal vertebrae	—	21	19	20
Caudal vertebrae	—	18	18	17

Three of these four specimens have 37 vertebrae, corresponding with our juveniles, and disagreeing with Kishinouye. Mr. Clothier has also advised us that, in addition, H. C. Godsil of the same laboratory, has examined two specimens from near Magdalena Bay each of which had 37 vertebrae. It appears that *E. lineatus* has 37 vertebrae as a rule. The vertebrae counts of our juveniles agree, then, with those of adult *E. lineatus* identified from other characters. All other characters examined agree well enough with Kishinouye's descriptions, and it was therefore concluded that these were juveniles of *E. lineatus*.

There are few references to juvenile *Euthynnus* in the literature. Kishinouye's (1923: 388) smallest specimens, 13 cm. in length, from the Asiatic side of the Pacific, were larger than any of ours. He described them as follows: "They are very slender and have eight or more transverse bands on the side. These bands are nearly vertical and fade toward the ventral median line. When they grow to a total length of 19 cm. the body becomes very broad, the thoracic spots appear, the bands gradually disappear from the ventral part and the dorsal part of the bands becomes oblique."

Ehrenbaum (1924) found among the Mediterranean collections of the Danish Oceanographical Expeditions six young tunas, 5.9 to 10.1 mm. in length, which he referred to *Euthynnus alliteratus* (Raf.). He differentiated these specimens from those of *Auxis thazard* only with great difficulty, on the basis of the first dorsal rays. The identification seems doubtful, but, since none of our specimens of *Euthynnus* are as small as Ehrenbaum's, we cannot verify it.

Auxis thazard (Lacépède) 1802

As is the case with many of the scombroids, there is some doubt as to whether there is a single cosmopolitan species of *Auxis* or whether different species occur in different parts of the world. The solution of this problem is beyond the scope of this paper and our juveniles are referred to *Auxis thazard*. No adult specimens were examined by us during this voyage, but the capture of juveniles indicates that this species spawns in Central American Pacific waters during the early spring. Juveniles were taken at the following stations on the dates indicated: 08° 20′ N., 84° 10′ W.; March 18, 1947; 2 specimens, 67 and 68 mm. total length. 09° 43′ N., 85° 54′ W.; March 19, 1947; 52 specimens, 21 to 53 mm. total length. 08° 7′ 30″ N., 83° 8′ 30″ W.; May 7, 1947; 3 specimens, 23 to 41 mm. total length. 09° 43′ N., 85° 54′ W.; May 17, 1947; 1 specimen, 42 mm. total length. Through the courtesy of Dr. J. T. Nichols, we were also able to examine 5 specimens, 22 to 31 mm. in total length, taken under a light at night from the "Askoy" at 04° 01′ N., 80° 26′ W. on March 24, 1941. Nichols and Murphy (1944: 241) suggest that these may be young *Euthynnus*, but they are undoubtedly *Auxis*.

Representative specimens of juvenile *A. thazard* are shown in Figures 3 and 4. In the smaller specimens the prominent areas of pigmentation are on the upper and lower jaws, above the snout, around the postero-ventral margin of the orbit, on the upper operculum, between the orbits, along the mid-line of the body, along the bases of the dorsal and anal fins

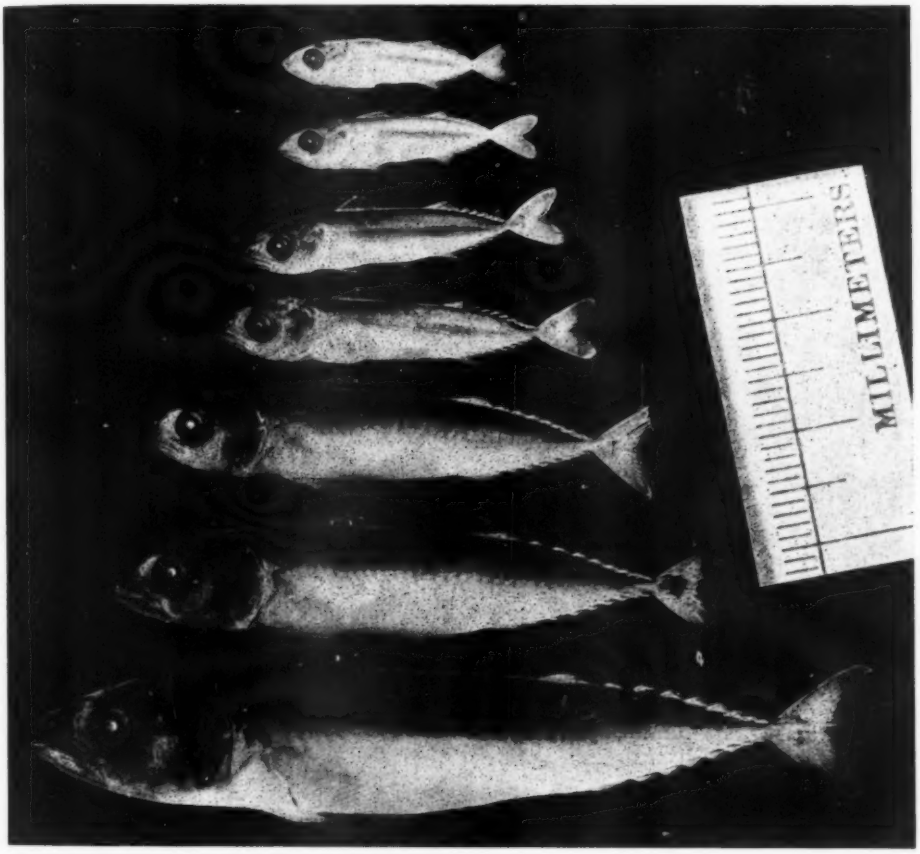

FIG. 3. Photograph of juvenile *Auxis thazard* (Lacépède).

including the finlets, and around the posterior end of the urostyle. Large chromatophores in the peritoneum show through the body wall along the upper half of the body cavity. None of the fins or finlets bears pigment spots, with the exception of the first dorsal. The first dorsal bears a few scattered chromatophores, largely distributed along the spines. However, the first dorsal in general appearance is virtually colorless, as may be seen in Figure 4, especially as contrasted with *Euthynnus* or *Neothunnus*. With increasing size the local areas of pigmentation expand. In our largest specimens the head is well pigmented. The dorsal half of the body is uniformly dark. This dark area extends below the mid-line on the caudal peduncle. The chromatophores in the peritoneum are no longer visible through the thickened body wall, and the ventral surface is unpigmented. Even in our largest specimens none of the fins is heavily pigmented; the caudal is more pigmented than the others.

Juvenile *Auxis* are rounder in cross section than *Euthynnus*, being relatively less compressed laterally. The head length and length of the caudal region in *Auxis* are less in comparison to the total length than is the case in *Euthynnus*. The maxillary in *Auxis* generally

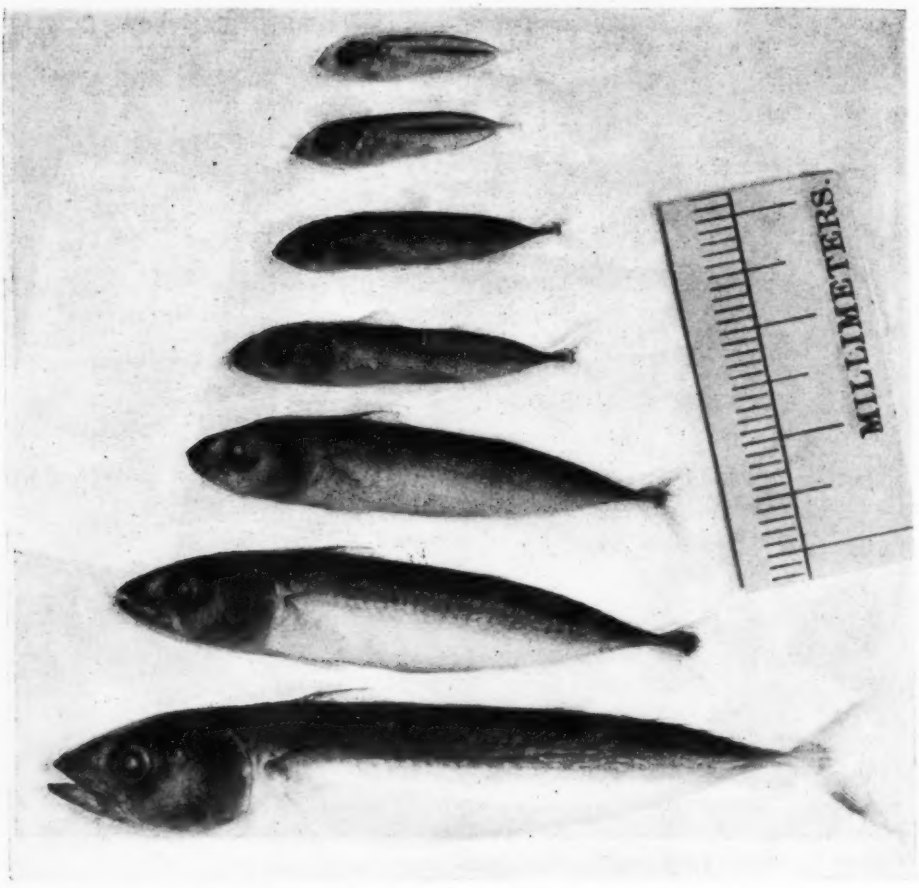

FIG. 4. Juvenile *Auxis thazard* photographed against a white background, illustrating lack of pigmentation of fins.

extends to a point between the anterior margin of the iris and the vertical bisector of the iris, whereas in *Euthynnus* it generally extends to a point between the vertical bisector of the iris and the posterior margin of the iris. In the smaller specimens the lower jaw is shorter than the upper, but the jaws become equal at about 50 mm. total length. The smallest specimens have three spines at the angle of the preopercle, but these are gradually grown over and disappear at about 35 to 40 mm. total length. There are indications, on alizarin-stained specimens, that seven more spines are present in smaller individuals. Similarly, a figure of a 17.5 mm. specimen of *A. thazard* from the Mediterranean (deBuen, 1932: Fig. 27) shows a total of nine preopercular spines. The lateral keel along the caudal peduncle starts to develop at about 40 mm. total length.

The large dorsal interspace characteristic of *Auxis* actually contains small spines or rays. These are usually subcutaneous. Even in our smallest specimens they are not visible unless the fish is cleared and stained or unless the

specimen is shrunken from the preservative so that the spines project above the dorsal profile. In adult *Auxis* from Culion, Philippine Islands, examined through courtesy of Dr. G. S. Myers of the Stanford University Natural History Museum, the interneural supports of the suppressed rays are well developed; the rays themselves are vestigial, however, and can be found only by staining and dissection. Fin ray counts on our stained juvenile specimens are as follows:

	mm.	mm.	mm.
Total length of specimen	25	31	46
First dorsal	11	11	11
Dorsal interspace	6	7	8
Second dorsal	12	11	11
Dorsal finlets	8	8	8
Anal	14	13	13
Anal finlets	7	7	7
Ventral	7	7	7
Pectoral	22	23	25

Other, unstained, specimens also have eight dorsal finlets and seven anal finlets. In the smaller specimens the finlets are joined by a membrane that extends completely or nearly to their distal ends. With increasing size this membrane becomes less prominent until in our longest specimens it is wanting or exists only between the bases of the finlets.

In all our specimens, each side of the upper jaw bears about 20 small, conical teeth; each side of the lower jaw about 25 small, conical teeth; each palatine 6 or 7 teeth; and the vomer none. The vomer and palatines are exposed. Starks (1910: 97), with reference to *Auxis thazard*, and Kishinouye (1923: 460), with reference to the genus *Auxis*, state that there are no palatine teeth, and this is apparently true in the adults. In the two adults from Culion, Philippine Islands, the vomer and palatines are toothless and are not exposed. These specimens are probably *Auxis bira* Kishinouye.

The gill rakers on the most anterior gill arch of our smallest specimens are very tiny projections and are difficult to count. They are first apparent near the angle of the arch. With an increase in the size of the fish, the rakers near the angle of the arch increase in length and new rakers are added distally on each arm. The full complement of rakers is apparently attained at about 50 mm. total length, as judged by the following counts on specimens of various sizes:

21 mm.	4 + 18
24 mm.	5 + 21
27 mm.	6 + 24
32 mm.	9 + 26
42 mm.	9 + 30
46 mm.	10 + 31
52 mm.	12 + 36
54 mm.	11 + 35
68 mm.	11 + 31

Gill raker counts on the adult specimens referred to above are 12 + 34 and 11 + 32. Kishinouye (1923: 462–3) gives 9 + 30 as the gill raker count for *A. bira* and 10 + 36 as the count for *A. maru* Kishinouye. Possible variation in these counts is not mentioned. He does not list *A. thazard*, but *A. maru* is probably a synonym of *A. thazard*, as he tentatively suggests in his synonymy.

The nasal rosette is visible only in cleared specimens.

The vertebrae were counted as 20 + 19 (including the urostyle) in three cleared and stained specimens. This agrees with Kishinouye (1923: 452) and Frade and deBuen (1932: 70), but disagrees with Starks (1910: 97), who counted 22 + 15 vertebrae. On a specimen 46 mm. total length, small ventral foramina are present on the 9th to 15th caudal vertebrae. On smaller specimens of 25 and 31 mm. total length, these foramina are not discernible, if present. In our specimens, the pedicles (of Starks = epihaemal process of Kishinouye) of the caudal vertebrae, bearing the closed haemal arches, are extremely short or non-existent. In a specimen of 25 mm. total length, the haemal arches of the caudal vertebrae are long, wide, and elliptical. In a specimen of 46 mm. total length, the haemal arch

is still long, but less wide. In a specimen of 72 mm. total length, the haemal arch is still long, but even less wide. In fact, the pedicle is divided and contains a large part of the haemal arch. In the two smaller specimens, the haemal arch is certainly closed on the 18th abdominal vertebra and is probably closed on the 17th vertebra; it is definitely open on the 16th vertebra. In the 72 mm. specimen, the haemal arch is open on the 17th vertebra and closed on the 18th. Kishinouye (1923: 339) states that the first closed haemal arch of *Auxis* occurs on the 1st caudal vertebrae (= 21st). In an adult specimen examined through the courtesy of Dr. G. S. Myers, the first closed haemal arch is on the first caudal vertebra. This specimen is from Wakanoura, Japan, and is referred to *Auxis hira.* We have been unable to examine any adult *Auxis* from the eastern Pacific in order to attempt to resolve this apparent discrepancy. C. R. Clothier has informed us that one specimen from the vicinity of Sebastian Viscaino Bay and two from the vicinity of Espiritu Santu Island, all identified as *A. thazard,* have a total of 39 vertebrae with the first haemal arch on the 21st vertebra. It seems unlikely that haemal arches that are closed would, with growth, become open. Our specimens may, therefore, be juveniles of an undescribed species. It is not unlikely that the sides of the pedicle fuse with an increase in size of the fish so that the haemal arch becomes greatly reduced in size. The possibility exists, however, that it may remain divided in this form.

The liver is divided into three lobes. The right lobe is almost as long as the visceral cavity and bears a prominent hepatic vein on its outer surface; the other two lobes are small. The stomach is long and lies above the rest of the viscera. The caecal mass is considerably shorter than the stomach. The intestine is relatively short, straight, and not folded. It runs posteriorly along the right inferior side of the stomach. There is no air bladder.

The vertebral count, the great length of the right lobe of the liver, the presence of a caudal keel, and the absence of an air bladder indicate that these juvenile scombroids belong to the family Katsuwonidae. The large interspace between the dorsal fins and the low ray count of the first dorsal, as well as the absence of the elaborate "trellis" of the vertebrae, indicate that they are *Auxis,* rather than *Euthynnus* or *Katsuwonus.* In the larger specimens, gill raker and fin ray counts will also serve to separate *Auxis* from the other genera. Positive specific allocation must await examination of adult specimens from the area.

A specimen of *A. thazard,* 17.5 mm. long, from the Mediterranean, was described and figured by deBuen (1932: 36–38). This is somewhat smaller than our smallest specimen and the differences between them, such as differences in numbers of preopercular spines, etc., are probably due to the differences in size. Sparta (1933: 16) mentions that specimens of *Auxis bisus* Bonaparte (= *A. thazard* Lacépède) about 1 cm. in length have been collected under a light at night in the Straits of Messina. Ehrenbaum (1924: 33–38) reported on 132 juvenile *A. thazard* from the Mediterranean collections of the Danish Oceanographical Expeditions. His largest specimen was 12 mm. in length, or about 9 mm. shorter than our smallest specimen. Again, differences between his descriptions and our specimens may probably be attributed to differences in size. These specimens were apparently taken in May, July, August, and September. He states that Sanzo found ripe ovaries in June and July. Sella (1924) describes Mediterranean specimens of *A. bisus* Bonaparte (= *A. thazard* Lacépède) ranging from 3 to 10 mm. These are much smaller than our specimens. He states that juveniles up to 10 to 15 mm. in length are found from the second half of June to September 20. He also mentions that before a length of 12 to 15 mm. is attained, about six rays are formed in the membrane connecting the first and second dorsal

fins and that these rays subsequently become contained in the median furrow so that they are no longer visible. This is in accord with our findings. The dates of our collections indicate the possibility of a somewhat earlier spawning season for *Auxis* off the Pacific Coast of Central America.

We have been unable to examine papers by Sanzo (1909, 1910) which apparently contain information on larval and juvenile *Auxis*.

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Plant Records from the Caroline Islands, Micronesia: Pacific Plant Studies 8[1]

HAROLD ST. JOHN[2]

AFTER THE CLOSE of active hostilities in the Pacific in 1945, the United States Navy made it possible for the University of Hawaii to send a scientific reconnaissance party into the Caroline Islands, even though thousands of Japanese military prisoners and a few detachments of hostile "hold-out" bands were still there. Plant collections were made on Kusaie Island from December 24 to 26, 1945; and in the Palau Group, on Angaur Island, on January 2, 1946. Below are listed the species taken which have not previously been recorded from these islands or for which the vernacular names used by the natives have not been recorded. The specimens are deposited in the Bishop Museum, Honolulu.

PLANTS FROM KUSAIE

ANGIOPTERIDACEAE

Angiopteris Beecheyana de Vriese

A. evecta sensu Hook. and Grev. non Hoffm., fide Hosokawa, Nat. Hist. Soc. Formosa, Trans. 26: 44, 1936.

Kusaie Island: divide S. of Lele Harbor, *St. John 21,440*, "taime."

OPHIOGLOSSACEAE

Ophioglossum pendulum L.

Kusaie Island: divide S. of Lele Harbor, *St. John 21,443*, "karkarweh."

CYATHEACEAE

Cyathea nigricans Mett.

C. affinis sensu Kanehira, non Schrader.

Kusaie Island: divide S. of Lele Harbor, trunks 8 m. by 2 dm., *St. John 21,441*, "po."

SELAGINELLACEAE

Selaginella Kanehirae Alston

Kusaie Island: Yekala Waterfall, *St. John 21,437*.

PANDANACEAE

Freycinetia ponapensis Mart.

Kusaie Island: Innemu River, *St. John 21,449*, "fuka."

HYDROCHARITACEAE

Thalassia Hemprichii (Ehrenb.) Aschers.

Kusaie Island: Lele Harbor, in salt water 1–2 m. deep, and on outer reef, *H. St. John and H. I. Fisher 21,453*. First record for Kusaie, though abundant in the shallow water of the harbor.

LILIACEAE

Cordyline terminalis (L.) Kunth

Taetsia fruticosa (L.) Merr.

Kusaie Island: divide S. of Lele Harbor, in moist native forest, *St. John 21,442*, "ing-in-kal." First record for Kusaie.

DIOSCOREACEAE

Dioscorea korrorensis R. Knuth

Kusaie Island: Lele Island, cultivated, *St. John 21,435*, "ohkani." First record from Kusaie.

[1] This is the eighth in a series of papers designed to present descriptions, revisions, and records of Pacific island plants. The preceding papers were published as *Bernice P. Bishop Mus., Occas. Papers* 17 (7), 1942; 17 (13), 1943; 18 (5), 1945; *Amer. Fern Jour.* 35: 87–89, 1945; *Torrey Bot. Club, Bul.* 73: 588, 1946; *Pacific Sci.* 1: 116, 1947; *Pacific Sci.* 2: 96–113, 1948.

[2] Chairman, Department of Botany, University of Hawaii. Manuscript received September 1, 1947.

RHAMNACEAE

Colubrina asiatica (L.) Brogn.
Kusaie Island: divide S. of Lele Harbor, *St. John 21,439*, "la."

VERBENACEAE

Premna integrifolia L.
Kusaie Island: Innemu River, *St. John 21,452*, "fienket."

Plants from Palau

CAPPARIDACEAE

Capparis cordifolia Lam.
Angaur Island: coral sea cliff, *St. John 21,500*, "i-il-lel-lameng-ngernger."

VERBENACEAE

Callicarpa cana L.
Angaur Island: coral limestone sea cliff, *St. John 21,502*, "dup." First record from Angaur Island.

Clerodendrum inerme (L.) Gaertn.
Angaur Island: coral limestone sea cliff, *St. John 21,501*, "kellel-lap-ni." First record from Angaur Island.

RUBIACEAE

Hedyotis albido-punctata (Merr.) Fosberg
Oldenlandia albido-punctata Merr.
Angaur Island: coral limestone sea cliff, *St. John 21,503*, "ngesil." First record from Angaur Island.

A New Echiuroid Worm from the Hawaiian Islands and a Key to the Genera of Echiuridae[1]

WALTER K. FISHER[2]

SINCE ECHIUROID WORMS and their eggs provide excellent material for biological experimentation, it is regrettable that the principal Hawaiian species is without a name. This paper is intended to supply the deficiency.

I collected the type series in 1902, during the Hawaiian cruise of the "Albatross," in tide pools on the reef between Honolulu harbor and Waikiki. The material was sent to the late Professor H. B. Ward and only recently became available for study. A long sojourn in weak alcohol has caused deterioration of the specimens.

Genus ANELASSORHYNCHUS Annandale

Anelassorhynchus Annandale, 1922: 148. Type, *Thalassema branchiorhynchus* Annandale and Kemp.

Diagnosis: Resembling *Thalassema* s.s. in having the longitudinal muscle layer of the body of uniform thickness, without specialized longitudinal bands, but differing in having prolonged, often coiled, lips to the ciliated funnel of the nephridium.

The group contains about twelve species from warm, shallow waters with the exception of an undescribed species from off Monterey Bay, California, 1083 fathoms, bottom temperature 38.5° F.

Anelassorhynchus porcellus new species

Diagnosis: Nephridia four, all behind setae; a very long segment of intestine between end of foregut and beginning of siphon; anal vesicles very long with a special basal inflated portion attached to body wall by muscular frenula; no caecum; setae small, without interbasal muscle; proboscis fleshy, deciduous, the two margins meeting at base to form lower lip; skin rather thick in adult, with transverse verrucae, in contracted state; size 30 to 70 mm. in length, the diameter variable.

Description: Body wall rather thick in large specimens, slightly translucent in smaller ones; skin usually closely wrinkled transversely, so that the small, closely placed glandular swellings have a transverse alignment. In middle of body, owing to stretching of skin, wrinkles may disappear and glands flatten out so as to be practically indistinguishable. (It is pretty much a matter of accident in preservation.)

Setae small (3 mm. long), with well-marked hook, placed rather close together, only a short distance from mouth. No interbasal muscle uniting inner ends of setae; basilaterals rather weak.

Inner layer of muscles of body wall smooth; middle, longitudinal layer undifferentiated as in other species of the genus.

All four nephridia behind setae, variable in size, sometimes greatly distended by sex products. Lips of nephrostome prolonged and usually spirally coiled.

Deflated anal vesicles very long and characteristically swollen at base, which is attached to anterior side wall of cloacal cavity. Walls of this cavity thin and attached to body wall by many frenula which also involve the swollen basal portion of the vesicles (Fig. 1, *c*). In some specimens vesicles covered with tiny

[1] Published with permission of the Secretary of the Smithsonian Institution. Manuscript received April 13, 1948.

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brown spots, perhaps the nephric elements, although ciliated funnels cannot be recognized.

Alimentary canal very long and filled with coarse "sand." No caecum present. Foregut without obviously differentiated subdivisions recognizable from outward appearance. Segment adjacent to ring blood-vessel (B^2) sometimes set off by a slight constriction. Very long segment of the intestine, between B^2 and beginning of siphon, apparently without ciliated groove. (This presiphonal segment is generally short.) In one specimen 50 mm. long, with empty and relaxed intestine, presiphonal segment can be traced for 40 mm. before a break occurs. It is almost certainly longer. Foregut 25 mm. in length. In another specimen a segment about twice as long as foregut is without siphon, although siphon is recognizable over an extensive portion of the midgut. Entire intestine about ten times contracted body length; in specimens examined in a most wonderful snarl, complicated in all but one by sausage-like swellings filled with sand and shell fragments.

Vascular system (Fig. 1, *a*) of usual *Thalassema* type, with well-developed ring vessel and some slight variations in the details of the connection with the neurointestinal vessel (B^3). (It may be remarked that the length of the neurointestinal varies from half the length shown in Figure 1, *a* to five times that length, depending entirely upon position of the end of the forgut, which has great freedom of movement.) In one specimen, killed while passage from stomach to intestine was distended by sand, ring vessel (B^2) three times usual diameter in preserved specimens.

Type: In the collection of the United States National Museum.

Type locality: Honolulu; reef south of harbor, in tide pools, June 6, 1902. Collected by W. K. Fisher.

Specimens examined: Honolulu reef, 15; Puako Bay, Hawaii, 2. I have also examined several collected by R. W. Hiatt at Halape, Hawaii, where they were found in sand under rocks.

Discussion: This species is probably rather closely related to *Thalassema semoni* Fischer (1896: 338, Fig. 4; Amboina) but the description lacks all details of the alimentary canal and figures of importance: Proboscis lost; larger of the two specimens 55 mm.; skin bluish-gray, rather thin and translucent; musculature not split into bundles; papillae cover skin almost without intervals, though more concentrated at posterior end; setae small; nephridia four, with spiral tubes; anal vesicles thin, brown, longer than half the body; they are attached to body wall by muscles; caecum not observed. Fischer states (1914: 19) that *Thalassema sabinum* Lanchester (1905: 40, Tale Sab, Singora) is a synonym of *semoni.* However, Prashad (1919: Pl. 11, Fig. 10) figures a dissection of *sabinum,* which shows a well-developed caecum and short anal vesicles. The proboscis is adherent, being an important respiratory organ owing to the ecology of the species. This figure also indicates that the presiphonal segment of intestine is short. *A. sabinus* is obviously not close to *porcellus* and is probably not the same as *semoni.*

No true *Thalassema* has been recorded from the Hawaiian Islands. Other echiuroids which I have examined from the islands are: *Ochetostoma erythrogrammon* Leuckart and Rüppell, Nawiliwili, Kauai (A. E. Verrill), and Halape, Hawaii (R. W. Hiatt); *Ochetostoma manjuodense* Ikeda, Halape, Hawaii (R. W. Hiatt); *Anelassorhynchus inanensis* (Ikeda), Halape, Hawaii (R. W. Hiatt). There are undoubtedly other species present in these waters.

As the genera allied to *Thalassema* are rather difficult to distinguish, the following synopsis may prove useful.

Keys to other genera of Echiuroidea, principally Bonelliidae, and figures of anatomy will be found in Fisher, 1946.

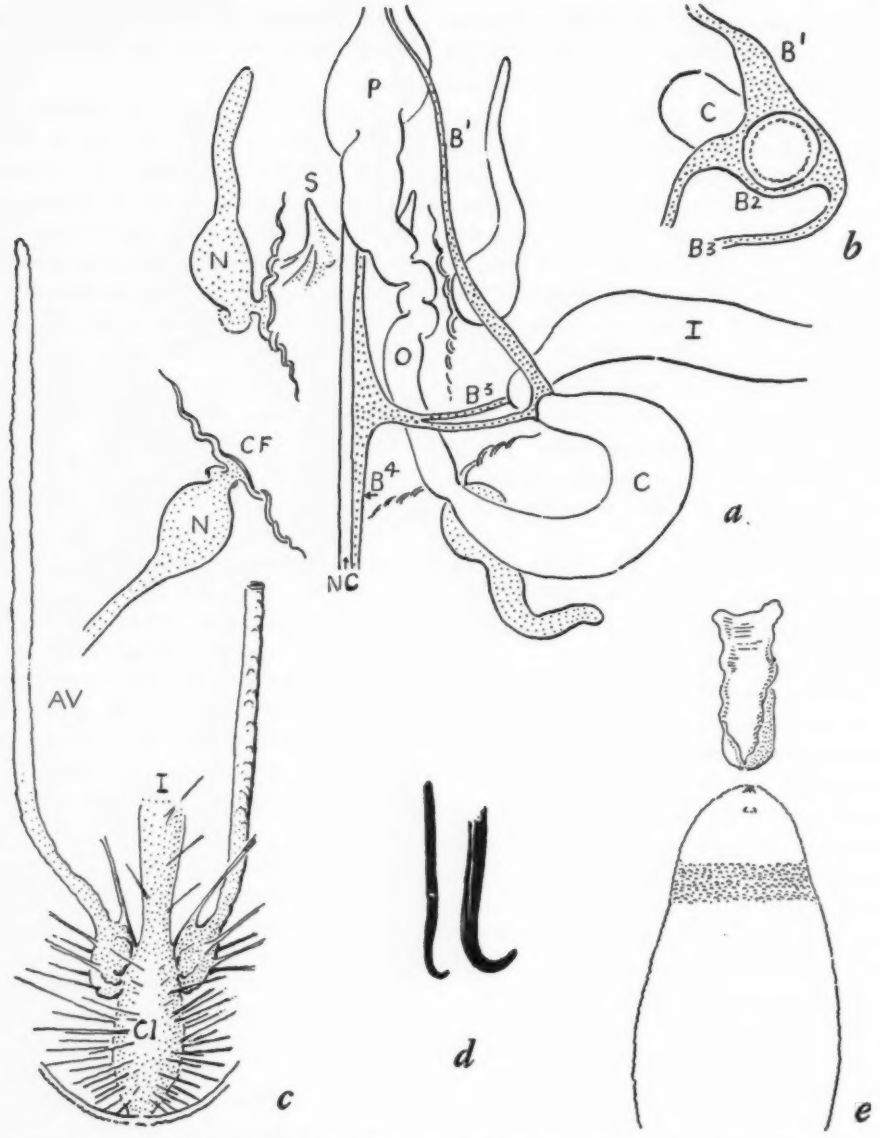

FIG. 1. *Anelassorhynchus porcellus: a,* map of anatomy of anterior portion of body, ×5, (mesenteries are omitted, the foregut [P,O,C] is capable of being straightened parallel to nerve cord so that the neurointestinal vessel [B^5] is then greatly lengthened, the nephridia [N] are usually greatly swollen by contained eggs or sperm); *b,* diagram of ring vessel surrounding end of foregut to show connection with B^1 and B^5; *c,* cloaca with anal vesicles, ×5, from a smaller specimen than *a*; *d,* seta, ×10, and its hook, enlarged; *e,* sketch of anterior two-thirds of a typical specimen with detached proboscis, ×1.

AV, anal vesicles; B^1–B^4, dorsal, ring, neurointestinal, and ventral blood vessels, respectively; C, stomach; CF, ciliated funnel or nephrostome; C, cloaca; I, intestine; N, nephridium; NC, nerve cord; O, oesophagus; P, pharynx; S, seta.

KEY TO GENERA OF ECHIURIDAE

a¹. Two circles of posterior setae.....*Echiurus* Guérin-Méneville
a². No posterior setae present
  b¹. No differentiated thicker bands in longitudinal muscle layer
    c¹. Nephrostome of nephridia without elongated spirally coiled lips
      d¹. The neurointestinal blood vessel in direct connection with dorsal vessel directly by a ring vessel or indirectly by a ring vessel at end of foregut; segment of intestine between ring vessel and beginning of siphon short and with ciliated groove; nephrostome with inconspicuous lips; proboscis not especially expanded at tip, often deciduous.....*Thalassema* Lamarck
      d². Neurointestinal vessel connected with dorsal vessel by numerous capillaries in wall of gut; segment of intestine between stomach and beginning of siphon very long (2 or 3 times body length) and with or without ciliated groove; nephrostome with conspicuous flap-like lip; proboscis very deciduous, long, slender, expanded at tip*.....*Arhynchite* Sato
    c². Nephrostome with elongated, spirally coiled lips....*Anelassorhynchus* Annandale
  b². Longitudinal muscle layer with slight to pronounced differentiation into longitudinal muscle bands, 6 or more in number
    c¹. Nephrostome of nephridia with small circular lips; inner layer of muscles not differentiated into separate transverse fascicles between longitudinal bands.....*Lissomyema* Fisher
    c². Nephrostome with elongated spiral lips
      d¹. Differentiated muscle bands weak, the zones between not showing a fasciculate arrangement of inner oblique muscles; in small specimens longitudinal bands very faint or visible only in posterior region.....*Listriolobus* W. Fischer
      d². Longitudinal muscle bands strongly developed; zones between crossed by separated fascicles of innermost oblique layer
        e¹. Nephridia in 1 to 5 pairs; vascular ring vessel at beginning of midgut.....*Ochetostoma* Leuckart and Rüppell
        e². Nephridia, at least in male, in 6 to 14 groups of 1 to 4, the groups arranged in pairs; vascular ring vessel at posterior end of pharynx.....*Ikedosoma* Bock

* I have specimens of a new form from off California in which the proboscis is present. In the two described species there seemed to be no trace of a proboscis scar.

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A Chronology of the Explosive Eruptions of Kilauea

HOWARD A. POWERS[1]

INTRODUCTION

THE EXPLOSIVE ERUPTIONS of Kilauea, both prehistoric and historic, have been much discussed in the literature on Hawaiian volcanoes. Some early general observations attributed all of the surface ash deposits to the known explosive eruption of 1790 (Dana, 1891: 42–45; Jaggar, 1921: 114–118); others recognized evidence of several different prehistoric explosions (Hitchcock, 1911: 166–169; Sidney Powers, 1916). Later studies, with better exposures in artificial cuts on the windward rim of the crater, demonstrated a number of long intervals of quiet between several eruptions (Finch, 1925; Stone, 1926). This paper adds another, still more detailed, chapter to the accumulated knowledge, but much remains to be learned and recorded before complete understanding of the explosive phases of the volcano is attained. Many of the thoughts expressed herein are the result of discussion and exchange of ideas in the field with many coworkers, whose contributions are gratefully accepted and acknowledged. T. A. Jaggar, R. H. Finch, E. G. Wingate, A. E. Jones, all formerly with the Hawaiian Volcano Observatory; J. E. Doerr, Jr., former naturalist, Hawaii National Park; H. S. Palmer of the University of Hawaii; C. K. Wentworth of the Honolulu Board of Water Supply; and G. A. Macdonald of the United States Geological Survey have all contributed to the accumulation and consideration of material which is presented in this paper.

The erratic original deposition of the pyroclastics of Kilauea, controlled by combinations of atmospheric elements and directed explosions, has been amply discussed by Wentworth (1938: chapter 3). Very few individual beds of material could be traced with assurance as horizon markers, even for the short distance around the circumference of the crater, because of this erratic deposition. Also, removal of material by wind and water erosion during and between eruptions has been tremendous. As a net result of these two factors, there is no cross section in the area which contains a complete representation of all the explosion deposits.

Successful analysis of the stratigraphy and chronology of these deposits thus depends as much on appraising an erosion surface in the section as upon correctly describing the beds of pyroclastic materials. In this study, great emphasis has been placed on recognition of characteristics which can be used to distinguish unconformities and erosion surfaces produced during time intervals of perhaps a few hours between explosions from those produced during time intervals measured in years or tens of years between eruptions. The following characteristics of the present desert surface have been used to identify similar long-exposed surfaces in cross sections of the deposits: surface oxidation, encrustation, desert varnish on fragments, concentration of coarser particles, thinly laminated dust deposits, and truncation of previously consolidated layers (Plate 1B and 1C). Humus and other remains of plant growth are self-evident where they exist.

On each of eight segments of the crater rim, a complete composite section of the pyroclastic deposits was built up by compilation from a number of cross sections which were sufficiently close together so that correlations between them could be made with confidence. Particular attention was paid to recording depositional

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TABLE 1. GENERALIZED SECTION OF PYROCLASTIC DEPOSITS, KILAUEA RIM.

≈≈≈ indicates humus layer.

ERUPTION	TYPE	MAXIMUM THICKNESS	LOCATION OF MAXIMUM THICKNESS	THICKNESS ON WINDWARD RIM	TYPE OF SURFACE ON WINDWARD RIM
1924	Phreatic	18 inches	S.W. Floor Kilauea	1 inch	Forest
1815 ca.	Magmatic	48 inches	S.W. Rim Kilauea	0	
1790 ca.	Phreatic	45 inches	West Rim Kilauea	3 inches	
18–K	Phreatic	20 inches	S.W. Rim Kilauea	7 inches	Exposed
17–K	Phreatic	40 inches	S.W. Rim Kilauea	16 inches	Exposed
16–K	Magmatic	21 inches	S.E. Rim Kilauea	6 inches	
15–K	Phreatic	36 inches	S.W. Rim Kilauea	3 inches	
14–K	Phreatic	24 inches	S.W. Rim Kilauea	0	Exposed
13–K	Magmatic	80 inches	S.E. Rim Kilauea	10 inches	Exposed
12–K	Phreatic	10 inches	North Rim Kilauea	10 inches	
11–K	Phreatic	7 inches	N.W. Rim Kilauea	5 inches	Exposed
10–K	Phreatic	12 inches	S.W. Rim Kilauea	2 inches	Exposed
5–K to 9–K	Magmatic	175 inches (about)	S.E. Rim Kilauea	25 inches	
3–K to 4–K	Magmatic	200 inches (about)	S.E. Rim Kilauea	30 inches	
2–K	Phreatic	11 inches	N.E. Rim Kilauea	11 inches	
1–K	Magmatic	12 inches	N.E. Rim Kilauea	12 inches	? ?
	Lava Flows	400 feet	North Rim Kilauea		
5–U	Magmatic	8 inches	N.W. Wall Kilauea		
4–U	Magmatic	8 inches	N.W. Wall Kilauea		
3–U	Magmatic	8 inches	N.W. Wall Kilauea		
2–U	Magmatic	12 inches	N.W. Wall Kilauea		
1–U	Magmatic	18 inches	N.W. Wall Kilauea		

breaks, erosional breaks, and breaks representing exposure as a surface for an important time interval. The thickest "blanket" occurrence (contrasted to pocket accumulations) in each small area is stated as the thickness of individual layers in the composite section; likewise the greatest number of separate layers found in each small area is used to represent a given eruption series. Thus, the composite section cannot be duplicated in any single section in an area, but represents the maximum number and blanket thickness of recognizable layers in each area. Similarly, composite sections were compiled for areas away from the rim in each major direction.

Cross correlation of these composite sections, depending as much on correlations of time–interval patterns as on a few recognizable horizon layers, has yielded a composite stratigraphic column and chronologic sequence of explosive activity for Kilauea. This is summarized in Table 1; the details of the most critical sections and the writer's correlation between sections are presented in Table 2. Eruptions of the two separate series have been numbered serially, i.e., 1-U for the oldest Uwekahuna tuff eruption, and 1-K for the oldest Keanakakoi eruption.

An overestimate of the time represented by some of the erosion surfaces may have yielded too great a number of eruptions. On the other hand, eruptions of the magnitude of the 1924 explosions might easily have been omitted entirely because of failure to discover remnant patches of their deposits. On the present rim surface, diligent search will find only a few patches of 1924 ash remaining (Plate 1B and 1C). Comparable remnant patches, buried in the stratigraphic section, could easily be overlooked.

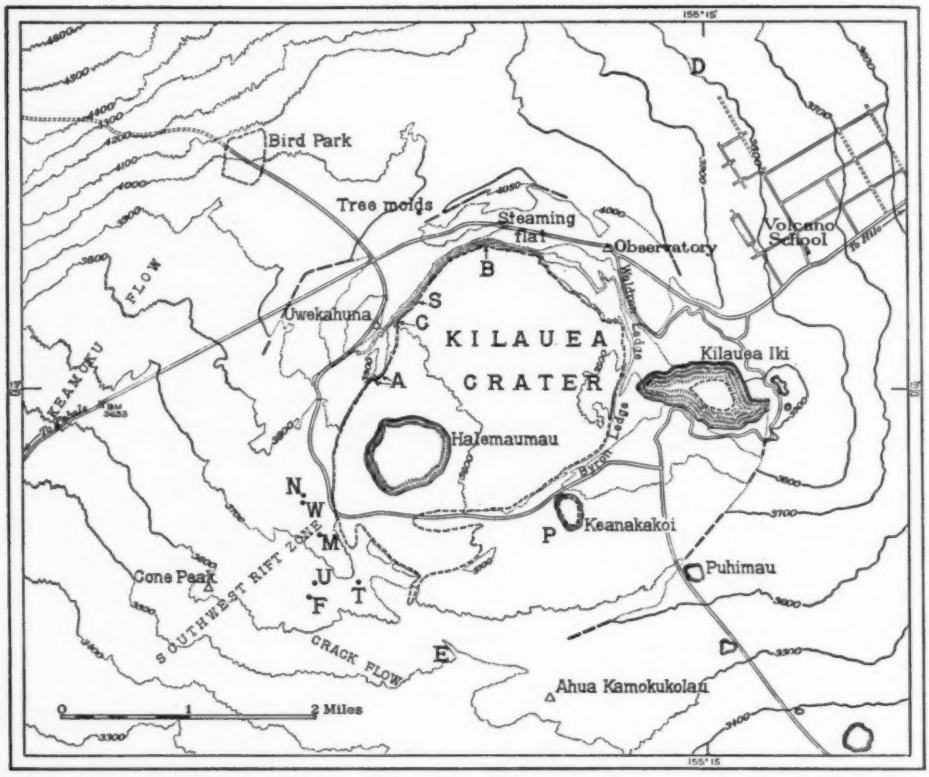


FIG. 1. Kilauea Crater and vicinity drawn from parts of the Glenwood and Kilauea Crater Quadrangles, U.S.G.S. topographic maps of Hawaii. Contour interval, 100 feet. Heavy contour lines are used on surfaces of the Kilauea dome which are apparently undisturbed by faulting; light lines are used for surfaces disturbed by faulting. Lettered localities are discussed in the text.

In the following text, it will be evident that descriptions of materials are presentations of fact, while appraisals of time intervals and cross correlations are presentations of the writer's interpretation.

UWEKAHUNA FORMATION

The oldest pyroclastic material which can be associated definitely with the central crater of Kilauea, the Uwekahuna formation (Stone, 1926: 27–28), is found in type locality in outcrops in the base of the northwest crater wall. The thickest section has been buried by the 1919 lava flow, but it was photographed by Jaggar in July, 1913 (Plate 2B), and cliff details in the photograph can be identified now in the field, making it possible to locate the exact position of the buried outcrop (locality A in Fig. 1 and Plate 2A) and to determine that the top of the tuff lies about 16 feet below the present surface of the 1919 pahoehoe lava at an estimated altitude of about 3,630 feet. This deposit was described by Sidney Powers (1916: 230) as "...exposed to a thickness of only 17 feet and for a length of about 500 feet, at the base of a cliff 170 feet in height." The present top of the cliff, above this deposit of

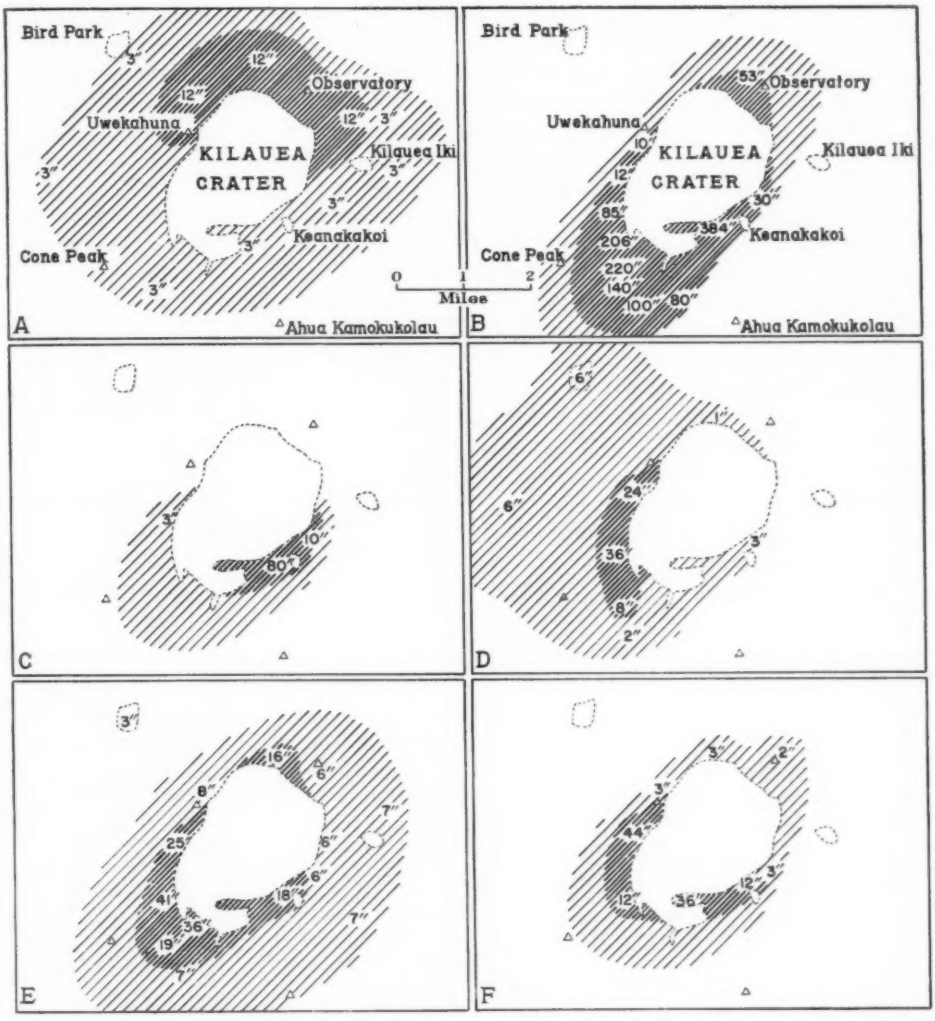


FIG. 2. Generalized pattern of distribution of several eruption deposits, shown at one-half the scale used in Figure 1. A, reticulite from eruption 1-K; B, composite vitric deposits from eruptions 3-K to 9-K, inclusive; C, vitric deposits from eruption 13-K; D, lithic deposits from eruption 15-K; E, lithic deposits from eruption 17-K; F, lithic deposits from the 1790 eruption.

Uwekahuna tuff, has an altitude of about 3,920 feet, indicating that the tuff lies beneath nearly 300 feet of bedded lava flows in the wall of the present crater, rather than the 170 feet suggested by Powers' sentence.

The most extensive occurrence of the Uwekahuna tuff is an apparently continuous, nearly horizontal deposit extending for about 5,000 feet (between localities B and C in Fig. 1 and Plate 3A), interbedded in the lavas of the northwest wall of Kilauea crater, and exposed in outcrops between talus fans at the base

of the cliff. At B the tuff is 3 feet thick, lies 10 feet above the present crater floor at an altitude of 3,560 feet, and ends abruptly to the northeast against the edge of a rim block which has slumped about 20 feet with respect to the rim section in which the tuff is exposed—enough displacement to bury the tuff layer beneath the crater floor if it continues into the slumped block. At C the tuff is exposed at the base of the crater wall at an altitude of 3,590 feet, then follows an unconformity which truncates some lava layers in the cliff, rising steeply to the southwest to an altitude of about 3,690 feet where it levels off for a short distance before it disappears to the southwest behind a rim block which has slumped about 300 feet with respect to the main crater wall containing the tuff outcrops (Plates 2A and 3A).

A third occurrence of tuff, interbedded in lavas of crater-rim age, is found at the bottom of the largest tree mold under the surface pahoehoe flow a third of a mile northwest of that corner of Kilauea crater (Doerr, 1933: 3–7). Here, a group of koa trees apparently grew in soil formed on a surface blanket of tuff. At least 20 of these trees were surrounded, without being toppled over, by the last lava flood which covered this part of the outer slope of Kilauea, and molds of their trunks are preserved in the congealed lava. The largest mold, having a maximum diameter of 7 feet and a depth of about 18 feet, is so located that it acts as a sump to drain the surface runoff from several acres, and erosion by water entering the mold has removed the tuff layer to form a cavern as much as 20 feet wide and 150 feet long, floored by an underlying pahoehoe lava surface and roofed by the bottom of the upper lava flow. The tuff exposed along the sides of the cavern ranges from 0 to 36 inches in thickness. It mantled the irregular surface of the underlying pahoehoe lava, and had been greatly eroded before burial by the surface flow. The tuff lies at an altitude of slightly over 4,000 feet. For reasons stated in the following paragraphs, this tuff is correlated with the Uwekahuna formation of the type locality.

The type deposit of the Uwekahuna tuff (in the base of the northwest crater wall) ranges in thickness from a few inches to over 7 feet. It consists of several beds of fine to coarse vitric pumice, intercalated with variable thicknesses of lithic debris mantling an unmodified surface of pahoehoe lava. A typical section (locality S on Plates 2A and 2C) is:

	Inches
Bottom of overlying lava	
Coarse vitric pumice	3
Oxidized desert surface	
Coarse pumice with a few lithic fragments	6
Oxidized desert surface	
Agglomerate of lithic dust and fragments	15
Oxidized desert surface	
Coarse pumice with a few lithic fragments	4
Oxidized desert surface	
Coarse vitric pumice	8
Oxidized desert surface	
Fine vitric shards grading down to coarser	12
Surface of underlying lava flow	

Most outcrops show the five layers of vitric material separated by oxidized desert surfaces; the amount, coarseness, and texture of the intercalated lithic debris vary greatly from outcrop to outcrop. The section on the outer slope of the Kilauea dome at the bottom of the tree mold consists of:

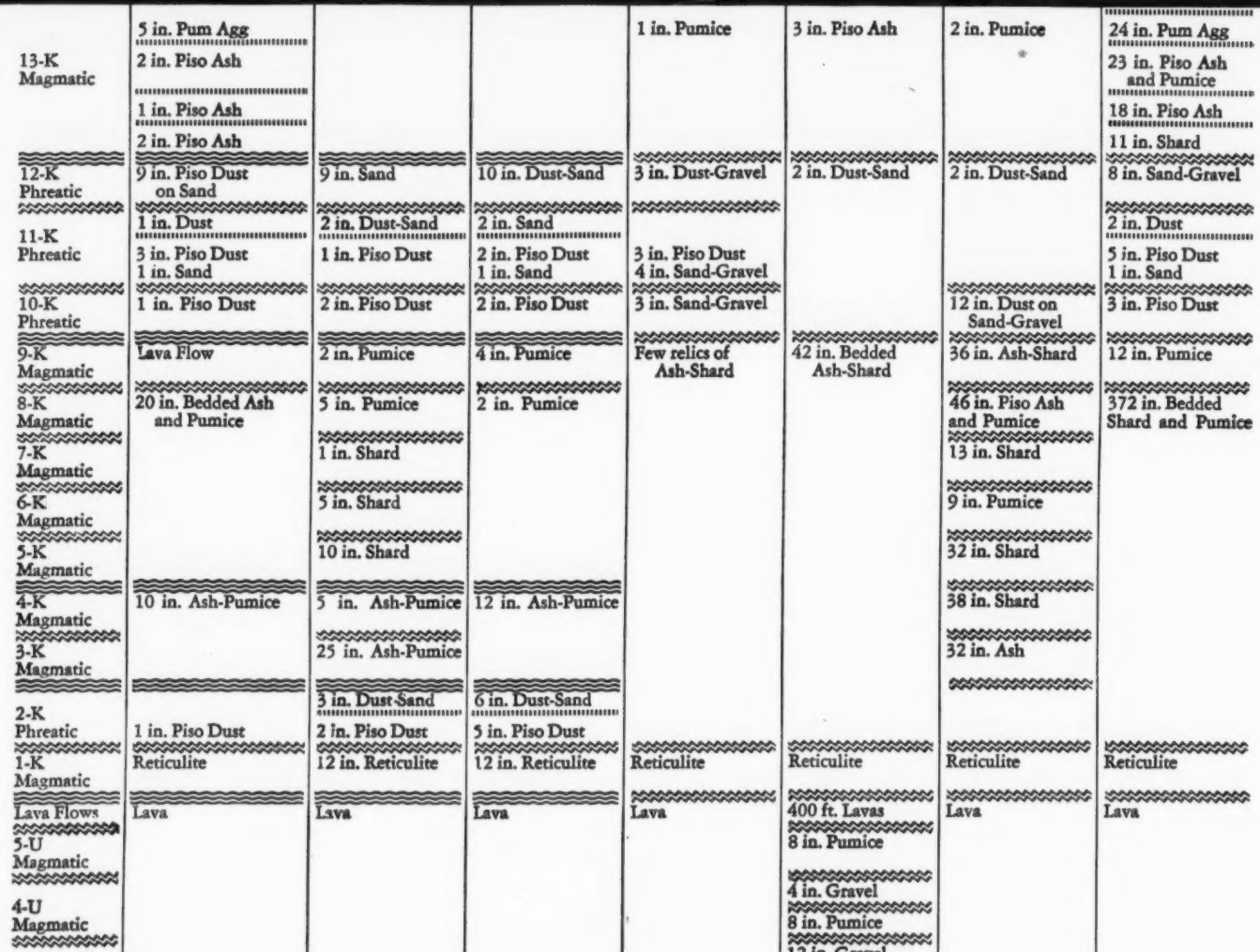
	Inches
Bottom of overlying lava flow	
Vitric pumice	2
Oxidized surface	
Medium vitric pumice	5
Oxidized surface	
Fine to medium, bedded vitric pumice	6
Oxidized surface	
Fine, bedded vitric pumice	9
Oxidized surface	
Very fine vitric ash and pumice	3
Surface of underlying lava flow	

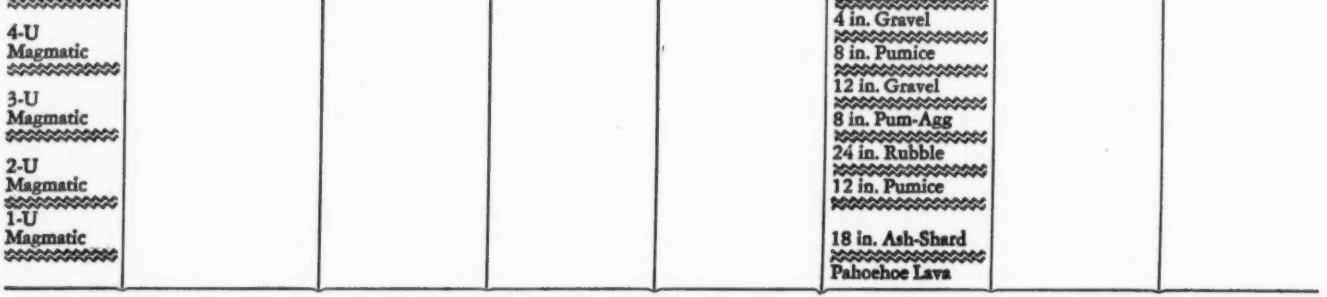
Thus, five epochs of magmatic fountaining, separated by times of quiet but with no intervening deposition of lithic debris, are represented at the tree mold locality. If the variable lenses of intercalated lithic debris are ignored in the type section, the five vitric layers in the

TABLE 2. CORRELATION OF COMPOSITE SECTIONS

The terms "dust," "sand," "gravel," and "rubble" refer to beds of crystal and lithic fragments, graded somewhat as to size of particle; the terms "ash," "shard," and "pumice" refer to beds of primary vitric fragments, graded similarly as to size. "Piso" denotes pisolitic structure of the fine materials, "agg" refers to an unsorted aggregate of lithic fragments ranging from dust to large blocks, and "pum agg" refers to rare beds of vitric lapilli which contain a few lithic blocks. Breaks between layers are represented by symbol lines as follows: breaks in deposition ·····; desert surface ≈≈≈; humus or soil surface ≋≋≋.

ERUPTION	S.E. RIM 3,775	N.E. RIM 4,000	N. RIM 3,950	N.W. RIM 4,075	W. RIM 3,900	S.W. RIM 3,750	S. RIM 3,650
					2 in. Piso Dust		
					4 in. Sand		
19-K	3 in. Gravel	2 in. Gravel	3 in. Gravel	3 in. Gravel	18 in. Gravel	12 in. Gravel	12 in. Gravel
1790 Phreatic					12 in. Dust on Gravel		
					8 in. Sand on Gravel		
	4 in. Piso Agg	2 in. Piso Agg	2 in. Piso Agg	2 in. Piso Agg		4 in. Piso Agg	6 in. Piso Agg
						2 in. Sand	
18-K Phreatic			1 in. Piso Agg	3 in. Sand	4 in. Gravel	4 in. Sand	6 in. Sand
	3 in. Sand		2 in. Dust on Sand	2 in. 4 prs. Dust on Sand	3 in. Dust on Gravel	10 in. 4 prs. Dust on Sand	1 in. Piso Dust
			1 in. Dust	1 in. Dust	1 in. Dust	4 in. Piso Dust	1 in. Piso Dust
				1 in. Sand	6 in. Sand-Gravel	6 in. Sand-Gravel	
17-K Phreatic		3 in. 4 prs. Sand-Gravel	9 in. 4 prs. Sand-Gravel	2 in. Sand	6 in. Sand-Gravel	15 in. 4 prs. Sand on Gravel	16 in. Bedded Sand-Gravel
	6 in. Sand-Gravel	3 in. Sand-Gravel	6 in. Gravel	4 in. Gravel	12 in. Gravel	16 in. Piso Dust on Rubble	2 in. Piso Agg
16-K Magmatic	1 in. Shard 2 in. Pum Agg 1 in. Shard	Pumice	1 in. Pumice	Pumice	Pumice	4 in. Piso Ash	3 in. Shard 18 in. Pum Agg
15-K Phreatic	3 in. Gravel		1 in. Piso Dust	24 in. Piso Dust-Rubble Agg	12 in. Piso Dust	36 in. Piso Dust-Rubble Agg	Remnant Blocks
					2 in. Piso Dust	12 in. Dust-Gravel	
14-K Phreatic				4 in. Sand	7 in. Dust-Sand	12 in. Dust-Gravel	
							4 in. Ash
	5 in. Pum Agg			1 in. Pumice	3 in. Piso Ash	2 in. Pumice	24 in. Pum Agg
13-K Magmatic	2 in. Piso Ash						23 in. Piso Ash and Pumice
	1 in. Piso Ash						18 in. Piso Ash
	2 in. Piso Ash						11 in. Shard
12-K Phreatic	9 in. Piso Dust on Sand	9 in. Sand	10 in. Dust-Sand	3 in. Dust-Gravel	2 in. Dust-Sand	2 in. Dust-Sand	8 in. Sand-Gravel
	1 in. Dust	2 in. Dust-Sand	2 in. Sand				2 in. Dust
11-K Phreatic	3 in. Piso Dust 1 in. Sand	1 in. Piso Dust	2 in. Piso Dust 1 in. Sand	3 in. Piso Dust 4 in. Sand-Gravel			5 in. Piso Dust 1 in. Sand
10-K Phreatic	1 in. Piso Dust	2 in. Piso Dust	2 in. Piso Dust	3 in. Sand-Gravel		12 in. Dust on Sand-Gravel	3 in. Piso Dust
9-K Magmatic	Lava Flow	2 in. Pumice	4 in. Pumice	Few relics of Ash-Shard	42 in. Bedded Ash-Shard	36 in. Ash-Shard	12 in. Pumice
8-K Magmatic	20 in. Bedded Ash and Pumice	5 in. Pumice	2 in. Pumice			46 in. Piso Ash and Pumice	372 in. Bedded Shard and Pumice
7-K Magmatic		1 in. Shard				13 in. Shard	
6-K Magmatic		5 in. Shard				9 in. Pumice	
5-K Magmatic		10 in. Shard				32 in. Shard	
4-K Magmatic	10 in. Ash-Pumice	5 in. Ash-Pumice	12 in. Ash-Pumice			38 in. Shard	
3-K Magmatic		25 in. Ash-Pumice				32 in. Ash	


5 in. Pum Agg
2 in. Piso Ash
1 in. Piso Ash
2 in. Piso Ash
13-K Magmatic
9 in. Piso Dust on Sand
1 in. Dust
12-K Phreatic
3 in. Piso Dust
1 in. Sand
11-K Phreatic
1 in. Piso Dust
10-K Phreatic
Lava Flow
9-K Magmatic
20 in. Bedded Ash and Pumice
8-K Magmatic
7-K Magmatic
6-K Magmatic
5-K Magmatic
10 in. Ash-Pumice
4-K Magmatic
3-K Magmatic
1 in. Piso Dust
2-K Phreatic
Reticulite
1-K Magmatic
Lava
Lava Flows
5-U Magmatic
4-U Magmatic
9 in. Sand
2 in. Dust-Sand
1 in. Piso Dust
2 in. Piso Dust
2 in. Pumice
5 in. Pumice
1 in. Shard
5 in. Shard
10 in. Shard
5 in. Ash-Pumice
25 in. Ash-Pumice
3 in. Dust-Sand
2 in. Piso Dust
12 in. Reticulite
Lava
10 in. Dust-Sand
2 in. Sand
2 in. Piso Dust
1 in. Sand
2 in. Piso Dust
4 in. Pumice
2 in. Pumice
12 in. Ash-Pumice
6 in. Dust-Sand
5 in. Piso Dust
12 in. Reticulite
Lava
1 in. Pumice
3 in. Dust-Gravel
3 in. Piso Dust
4 in. Sand-Gravel
3 in. Sand-Gravel
Few relics of Ash-Shard
Reticulite
Lava
3 in. Piso Ash
2 in. Dust-Sand
42 in. Bedded Ash-Shard
Reticulite
400 ft. Lavas
8 in. Pumice
4 in. Gravel
8 in. Pumice
2 in. Pumice
2 in. Dust-Sand
12 in. Dust on Sand-Gravel
36 in. Ash-Shard
46 in. Piso Ash and Pumice
13 in. Shard
9 in. Pumice
32 in. Shard
38 in. Shard
32 in. Ash
Reticulite
Lava
24 in. Pum Agg
23 in. Piso Ash and Pumice
18 in. Piso Ash
11 in. Shard
8 in. Sand-Gravel
2 in. Dust
5 in. Piso Dust
1 in. Sand
3 in. Piso Dust
12 in. Pumice
372 in. Bedded Shard and Pumice
Reticulite
Lava


4-U
Magmatic
3-U
Magmatic
2-U
Magmatic
1-U
Magmatic
4 in. Gravel
8 in. Pumice
12 in. Gravel
8 in. Pum-Agg
24 in. Rubble
12 in. Pumice
18 in. Ash-Shard
Pahoehoe Lava

type sections of the Uwekahuna tuff may be correlated satisfactorily with the five vitric layers found at the tree mold locality. Future study may indicate that the lithic debris represents deposits from phreatic eruptions; the present evidence suggests that the composition and distribution of the lithic lenses are too erratic even to represent phreatic eruption deposits. At present it is thought that they are talus debris and outwash material interbedded with the mantle deposits of pumice on the floor of an old crater near the base of an old crater wall.

Of the tuff pictured in Plate 2B, Sidney Powers (1916: 230) gives the following description: "The beds are composed principally of yellow ash with some rock-fragments 1–2 inches in diameter, lava droplets, thread-lace scoria, and a few bombs 6 inches in length." Wentworth (1938: 88) discounts the possible correlation of this tuff with the Pahala tuff. Macdonald thinks it may be a continuation of the tuff still exposed northeast of Uwekahuna and it is so considered by the writer.

To the northwest and the northeast, beyond the edge of Kilauea surface flows, a deposit of partly consolidated crystal-vitric tuff is found which possibly correlates in age with one of these Uwekahuna magmatic eruptions. In the Bird Park area (Fig. 1), this bed lies on palagonitized Pahala tuff under the edge of an aa flow from Mauna Loa, which in turn is older than the lowest member of the Kilauea surface-ash deposits. About two miles northeast of Kilauea, at about 3,800 feet (locality D, Fig. 1), a bed of coarse, slightly palagonitized vitric shards lies on top of the completely palagonitized Glenwood tuff under a layer of unaltered surface ash from Kilauea.

All of these tuff deposits are considered parts of the same formation—the Uwekahuna tuff—deposited on different parts of an older Kilauean dome with a collapse caldera in the summit. The tuff is considered to be the remnant deposits of five epochs of intense lava fountaining or magmatic explosion separated by intervals of relative quiet measured in at least tens of years.

Studies now in progress on the rate of reforestation in given climatic zones may eventually yield data making useful the state of reforestation as a quantitative indicator of elapsed time since a given area was a new volcanic surface. At present, the use of forest growth as an indicator of the age of a surface is not much better than intelligent guessing, but one is tempted to use it in evaluating the lapse of time between the eruption of the pre-Uwekahuna-tuff pahoehoe flow and the destruction of the koa grove by the post-tuff flow at the tree mold locality. Present climatic conditions between the tree mold locality and an area just northeast of Keanakakoi are not widely different; the average annual rainfall is approximately 60 to 70 inches at both places, with slightly more fog at the tree mold area. Deposits from the 1790 eruption average over a foot thick on the Kilauea rim just north of Keanakakoi, but thin to 3 inches in less than a quarter of a mile to the northeast. The present surface is practically barren of tree growth north of Keanakakoi, but supports a dense forest of ohia and amaumau fern a quarter of a mile to the northeast. In fact, the transition from dense growth to barren surface occurs in a zone about 300 yards wide in which scattered trees and ferns have obtained a foothold (Plate 1A). The conclusion seems justified that the 1790 deposit killed the surface vegetation up to a fairly sharp line and that the advance of reforestation over the new surface has progressed about 300 yards in 150 years. Judging from the present relationship of the slopes of Kilauea to the forested slopes of Mauna Loa, the tree mold area could not have been closer than half a mile (probably a mile) to living koa forest after the eruption of the pre-Uwekahuna surface lava flow. The trees which formed the molds hardly could have obtained foothold until the end of the second Uwekahuna magmatic explosion since its eruption of 9 inches of pumice at this spot probably would have killed

forest growth. The advance of the koa forest across more than half a mile of barren surface would seem to demand at least 300 years, and growth of the tree with a diameter of 7 feet would seem to require perhaps 300 years. The time lapse between emplacement of the two upper lava flows enclosing the Uwekahuna tuff could well approach 1,000 years.

Above the lower outcrops of Uwekahuna tuff, truncated by the present crater wall, are at least 30 pahoehoe flows ranging in thickness from 1 to 35 feet (Macdonald, in press) and separated by flow contacts which show no evidence of prolonged erosion or soil accumulation. This epoch of rapidly recurring eruptions of fluid lava apparently filled the supposed old crater, overflowed the old outer rim at least one flow deep on the northwest (the tree mold flow), and restored a constructional dome shape to the summit of Kilauea. Reconstruction of the probable shape of the dome by using present surface contours in segments that have not been faulted, and restoring the measurable amount of slump in the down-faulted segments, indicates that the probable summit of the dome was elongated east–west across the north end of the present caldera between Uwekahuna and the east end of Kilauea Iki. On Figure 1, the contours of the unfaulted Kilauea surface are indicated by a slightly heavier contour line.

This epoch of rapidly recurring overflow apparently closed with the collapse of at least part of the present caldera and with the start of a series of explosive eruptions which deposited the members of the Keanakakoi formation (Wentworth, 1938: 92) on the surface of the present caldera rim.

KEANAKAKOI FORMATION

The Keanakakoi formation includes all fragmental deposits emplaced on the present rim of Kilauea by explosive eruption of the summit crater. In theory it should represent all of the late explosive eruptions, but of necessity any explosions too feeble to deposit an appreciable layer of material on the rim exclude themselves because they have left no visible record. The present interpretation identifies deposits from 21 different explosive eruptions separated by breaks representing time lapses to be measured at least in years. Not less than seven of these breaks were long enough for re-establishment of a vegetative cover on the humid windward rim. Ten of the eruptions involved only phreatic explosions; 11 were magmatic explosions or intense lava fountaining.

The oldest layer of known pyroclastic material on the surface of the Kilauea rim lavas is the "reticulite" (Wentworth, 1938: 93) or "thread-lace scoria" (Dana, 1891: 163). In places on the northeast rim, thin patches of lavender clay are found on the lava under the reticulite, but it is not known whether this clay represents the remnants of an earlier explosive eruption deposit, or is merely surface detritus which was mechanically eroded from the surface of bare pahoehoe, concentrated into pockets, and mixed with accumulated humus. Oxidation of the glassy pahoehoe skin is found everywhere, though it cannot be demonstrated that this oxidation occurred before deposition of the reticulite. The surface of the clay pockets is also oxidized and contains humus, so it is quite probable that a vegetative cover had at least partially developed on the northeast rim prior to the eruption of the reticulite. This deposit can be found in blanket thicknesses of about 12 inches on the north and east rims of the crater (Fig. 2A). Thin blanket deposits and pocket accumulations have been found entirely around the rim and as far away as the Bird Park. It is found under the edge of the Keamoku aa flow from Mauna Loa.

It is difficult to appraise the time interval between deposition of the reticulite and its burial by the next eruption deposit. Charcoal fragments are found on the surface of the reticulite on the northeast rim. They may be relics of vegetation burned by the deposition of the reticulite, or they may represent vegetation

that grew on the surface of the reticulite. The reticulite is a material which could support vegetative growth and show very little decomposition or mixture with humus.

The second eruption was phreatic, and deposits from it are found only on the north and east rims. On the slumped rim-blocks below Waldron's Ledge along the Volcano House–Halemaumau Trail, are 36 inches of mixed, tan pisolitic clay and lithic fragments up to a cubic foot in volume. The deposit on Byron's Ledge, at the north end, is similar in make-up, but only 6 inches thick. On the Steaming Flat (N. Rim 3,950 in Table 2), the deposit consists of 5 inches of pisolitic tan clay overlain by 6 inches of layered dust and fine sand. This 11-inch blanket on the Steaming Flat probably would have destroyed existing vegetation. A humus layer on its top indicates that some soil was formed and a vegetative cover developed again before the next eruption. Scattered pumice is mixed in with the soil surface in many places, and a thin pahoehoe lava flow covered part of the north end of Byron's Ledge during this time interval.

Remnant deposits from the third and fourth explosive eruptions range in thickness from about 200 inches west of Keanakakoi (S. Rim 3,650 in Table 2) to 2 inches on the top of Uwekahuna Bluff (N.W. Rim 4,075 in Table 2). A 12-inch section on the Steaming Bluff consists of:

	Inches
Humus layer at old surface	
Fine vitric shards	2
Wind-blown vitric shards, dune-like	1
Fine vitric shards grading down to pumice	2
Depositional break	
Pea-size vitric lapilli	2
Depositional break	
Fine vitric shards grading down to pumice	2
Depositional break	
Fine vitric shards grading down to coarse pumice	3
Humus layer, surface of second eruption deposit	

The thickest section of these vitric deposits (near Keanakakoi) is in a cliff which is inaccessible for detailed study. In the walls of a gaping surface crack southeast of Cone Peak, under the crack flow, the section is 108 inches of alternating beds of fine, dun-colored pisolitic vitric shards and coarser pumice lapilli up to one-half inch in diameter. One mile east (locality E in Fig. 1), the section consists of about 80 inches of bedded, dun-colored vitric shards; another half a mile to the east, just northwest of Ahua Kamokukolau, the section is only 6 inches of unconsolidated, apparently wind-drifted, dun-colored vitric shards.

Following the deposition of these vitric beds in the third and fourth eruptions, a complete vegetative cover became re-established on the windward rim, and pronounced erosion occurred on the leeward rim (Plates 1D and 4B).

A series of at least five magmatic explosive eruptions next deposited beds of vitric shards and pumice totaling over 20 inches on the windward rim and over 130 inches on the leeward rim. A thin pahoehoe flow lies on top of this series on the southeast rim of Kilauea near Keanakakoi. The eruptions were separated by time intervals long enough to produce exposed surface features but too short to permit the growth of vegetative cover on the windward rim; however, recovery of the windward rim vegetation followed the last of these eruptions.

The small size and fragmental shapes of the shards making up a large part of these thick vitric beds and the presence of pisolitic structures, seem to indicate that the eruptions which produced them were more violently explosive than the lava fountains which have been observed at Kilauea (or Mauna Loa) in recent years. On the other hand, the explosions were less violent than some of the phreatic blasts which lifted fine material into the upper air above the trade winds, because the distribution of the vitric beds (Fig. 2B) is typical of deposition under trade-wind influence.

The extremely rapid thinning of these beds of vitric ash in all directions is very striking. Beds 100 inches in thickness half a mile due

southwest from the present leeward rim of the crater decrease to less than 10 inches in the next half mile to leeward. The size of particles decreases rapidly also; no particles reaching a diameter of ½ inch are found in the beds of the original blanket deposit at distances 2 miles to leeward. Pieces of frothy pumice considerably larger than this are found in pockets as much as 4 miles distant, but their occurrence indicates, without much question, that they have been skipped and rolled downhill by wind drifting. This very localized distribution of the products of the greatest vitric ash eruptions known to have come from the central crater of Kilauea, raises a serious question as to the ability of earlier Kilauea crater explosions to have contributed directly and appreciably to the ash deposits of Hilina Pali and similar areas over 10 miles from the central crater.

The next three eruptions, numbers 10, 11, and 12, were relatively weak phreatic explosions, as the lithic particles in their deposits are all smaller than medium gravel. The earlier deposit is thicker on the southwest rim, perhaps due to trade-wind control during deposition, while the latter two are thickest on the windward rim. The time intervening between each of these eruptions was insufficient for reforestation, but the time following the third one was long enough to produce a vegetative cover, as evidenced in the section on the southeast rim at the edge of the humid area. A good soil is present on the deposit from this twelfth eruption on the northwest rim, but it represents a telescoping of several ensuing time intervals and uninterrupted growth of vegetation up to the time of the seventeenth eruption.

The thirteenth eruption was essentially one of intense fountaining, but locally several of the explosions hurled out small amounts of wall-rock fragments (probably from talus piles within the craters) which are mingled with the pumice. The deposit is localized (Fig. 2C): 80 inches of coarse and fine pumice with a few lithic blocks are found on the south rim due west of Keanakakoi; 11 inches of bedded pumice with a few small lithic fragments are found on the southeast rim; and a few inches of pumice alone are found on the rest of the circumference of the crater. A thin pahoehoe flow, which issued from a concentric crack a mile southwest of the crater and flowed over several acres of surface, is correlated tentatively with this magmatic eruption.

In detail, the thickest section of this deposit consists of:

	Inches
Desert surface	
Fine vitric shards approaching dune sand	4
Textural break	
Bedded, fine to coarse pumice, some lithic fragments	24
Textural break	
Bedded, pisolitic vitric shards and coarse pumice	40
Textural break	
Coarse pumice	12
Surface of underlying material	

The fourteenth eruption was phreatic, and its deposits remain only on the west and southwest rim of the crater: 3 inches of lithic fragments up to half an inch in diameter on the west rim, and 24 inches of bedded lithic dust on medium to coarse lithic fragments on the southwest rim.

The fifteenth eruption was a phreatic explosion which deposited lithic blocks of over a cubic foot in volume more than a quarter of a mile beyond the present southwest rim and on Uwekahuna Bluff (Fig. 2D). At the southwest rim, the deposit is 36 inches thick and consists of large to small lithic blocks mixed through a matrix of pisolitic dust. Away from the crater rim, the lithic fragments play out rapidly from the thick layer of partly consolidated, fine pisolitic dust. At the contact of the Kilauea slope against Mauna Loa at the foot of Kipuka Puaulu (Bird Park), the section is over 6 inches thick, consisting of an upper layer of compact pisolitic dust, a middle layer of dust and fine lithic sand, and a lower layer of pisolitic dust. This bed mantles the lower mile of the Mauna Loa slope northwest of Kilauea. It

is 6 inches thick at B.M. 3,633 where the belt road climbs onto the edge of the Keamoku flow 2 miles west of the crater. At F in Figure 1, east of Cone Peak, the section shows oxidation of the upper members and consists of 4 inches of dust to fine sand, 1 inch of pisolitic dust, 2 inches of laminated dust on coarse sand, and 1 inch of medium-sized lithic sand.

The time intervening between the thirteenth and the sixteenth eruptions was long enough for a vegetative cover to develop on the southeast rim. The fact that oxidation is deeper (in the leeward sections) on the deposits of the fifteenth eruption than on either the thirteenth or fourteenth suggests that the greater part of the time interval occurred between the fifteenth and sixteenth eruptions.

The deposits of pumice, mixed with a few lithic fragments, of the sixteenth eruption are concentrated to thicknesses of 21 inches on the south rim near Keanakakoi. At the edge of the humid area (S.E. Rim 3,775 in Table 2) 4 inches of this pumice are topped with a good humus layer. Elsewhere the surface shows much erosion and oxidation of wind-blown surface material and carries abundant drift pumice and Pele's hair.

The remnant rim deposits of the seventeenth eruption range in thickness from 6 inches on the northeast rim to 41 inches on the southwest rim (Fig. 2E) and are sufficiently well preserved to suggest an appraisal of the explosive phases of the eruption. After an assumed preliminary stage which left no record on the rim, the first (recorded) phase was the most violent phreatic explosion of the eruption and was followed by a pause in which rains cleared the air of dust. This is suggested by the basal layer which is found as follows: 3 inches of lithic fragments ranging from coarse sand up to 3-inch diameter (a few blocks exceeding a cubic foot in volume) capped by a top film of fine sand and dust on the northeast rim; 24 inches of lithic fragments ranging from a quarter inch up to 6 inches (a few blocks of as much as 4 cubic feet in volume) capped by 1 inch of pisolitic dust on the southwest rim; and intermediate thicknesses of similar materials on the southeast and northwest rims. The second phase included at least four explosions following one another so closely that the air was not cleared of fine dust between them. The deposit on the northeast rim consists of four layers of coarse to fine lithic sand totaling about 3 inches, and on the southwest rim consists of four layers of lithic lapilli (up to ½ inch in diameter) grading into coarse lithic sand totaling about 15 inches in thickness. The third phase included one explosion followed by rains localized on the leeward side of the crater. This last explosion deposited a thin layer of lithic sand grading into about an inch of non-pisolitic dust on the windward rim and 6 inches of lithic lapilli and coarse lithic sand capped by 4 inches of pisolitic dust on the leeward rim.

No humus formed on these deposits on the windward rim, but the surface features indicate wind work, crustation, and oxidation characteristic of exposure for an interval at least of some years' duration. Pumice, Pele's hair, and Pele's tears scattered on the surface indicate lava fountaining during the interval.

The deposits from the eighteenth eruption range in thickness from 2 inches on the windward rim to 20 inches on the leeward rim. A possible separation of the explosions is again suggested by the details of the section on the southwest rim. At the start of the eruption, four relatively small phreatic explosions deposited a total of 10 inches on the southwest rim made up of four layers of coarse lithic sand, each capped by lithic dust, and a total of 2 inches of pisolitic lithic dust on the windward rim. Two more phreatic explosions deposited, respectively, a 4-inch and a 2-inch layer of coarse to fine lithic sand on the leeward rim and a 1-inch layer of pisolitic dust mixed with coarse lithic sand on the windward rim. Perhaps both of these phases occurred during trade-wind rains. The last explosion deposited an unsorted aggregate of lithic fragments in a matrix of tan pisolitic dust all around the rim, ranging

from 2 inches thick on the northeast to 12 inches on the south near Keanakakoi.

The surface of this deposit shows the effects of prolonged exposure and wind erosion (Plate 4C) in every area, but no humus layer accumulated on the windward rim.

The remnant deposits on the crater rim from the 1790 eruption (Finch, 1947: 1) range in thickness from about 3 inches on the windward rim to a maximum of about 44 inches on the broad fault block forming the inner, western rim of Kilauea (Fig. 2F). At this locality, the deposits indicate at least three main explosive phases. The lowest layer is 8 inches of lithic fragments (up to 2 inches in diameter) grading up into a thin layer of fine lithic sand. The middle layer is 12 inches of unsorted, fine to coarse, lithic fragments capped by a thin layer of lithic dust. The upper layer, 24 inches thick, consists of 18 inches of medium to large lithic blocks (up to 6 inches) grading up into 4 inches of coarse to fine lithic sand, grading into 2 inches of fine lithic dust. A mile south, on the southwest rim, the deposit is about 12 inches of unsorted, fine to coarse, lithic fragments, and it continues in similar thickness and composition around the south rim to the section due north of Keanakakoi. From this point northeast along the rim, the deposit thins very rapidly to 3 inches in less than a quarter of a mile (Plate 1A). On all of the windward rim, the deposit consists of unstratified material ranging from dust to pebbles approximating a hen's egg in size, now mixed with humus as well as some indistinguishable, fine material from historic eruptions. It makes up the bulk of the present surface soil, though there has been no chemical decomposition of the lithic fragments. On the leeward desert rim, except where it is covered by later deposits, coarse fragments from this deposit have been concentrated and fine material has been crusted to form the stony pavement characteristic of the desert surface.

The thickness of this deposit decreases rapidly in all directions away from the crater. A maximum thickness of 6 inches can be found on the outermost rim due west of Halemaumau at 3,800 feet altitude, on the broad slope east of Cone Peak at 3,600 feet, and due south of Keanakakoi at 3,600 feet. The size of fragments decreases and the proportion of dust increases with distance away from the crater rim. Many blocks with a volume exceeding a cubic foot and a few with a volume exceeding a cubic yard are found on the rim around the southwesterly half; fragments up to 6 inches in diameter are found to the southwest as far as Cone Peak; fragments up to 2 inches in diameter are not rare to the southwest as far as the 3,400-foot contour; and many fragments reach half an inch in diameter near Mauna Iki at 2,900 feet.

The deposit is made up almost entirely of crystalline fragments and contains no juvenile vitric pumice, though, in a small area, bread-crusted blocks and cored bombs are common. Near Keanakakoi, such fragments make up nearly 1 per cent of the deposit and blocks and cored bombs up to a cubic foot in volume are found as much as half a mile from the crater rim. They are very rare in the other quadrants of the crater rim. The insignificant amount of still-plastic material (at time of eruption) represented by these bombs is considered to have been "bench magma" left behind by the abrupt withdrawal of the active magma column, and the eruption is believed to have been made up entirely of phreatic explosions.

Correlation of specific eruption layers in sections somewhat distant from the rim of the crater is almost entirely speculative. On windward slopes an appreciable thickness of material was deposited by very few eruptions, and any thin deposits lost their identity by incorporation in the then-existing, surface soil. To leeward, immediate attack by wind erosion rapidly destroyed most thin layers of ash, adding the coarser materials to the moving sand dunes and transporting the fine material entirely out of the area in which it was deposited. Beds of water-saturated pisolitic mud which have been partly consolidated and sur-

face-crusted during the initial drying out are the only thin leeward layers which remain in place for an appreciable length of time.

In the belt of young ohia forest a mile northeast of the rim of Kilauea, the ash section and a possible correlation with the Keanakakoi series eruptions is:

	Eruption
4 inches of surface humus grading into next layer	
2 inches of lithic sand and fine gravel	1790
3 inches of pisolitic aggregate	18-K
7 inches of lithic sand and gravel	17-K
Humus layer	
8 inches of lithic sand and gravel	12-K
Humus layer	
2 inches of pumice mixed with humus	9-K
8 inches of vitric ash mixed with humus	8-K to 3-K
Humus layer	
2 inches of fine clay	2-K
8 inches of reticulite	1-K

Two miles to the northeast, in a more mature forest made up of ohia, tree fern, and koa, the section is:

	Eruption
Humus top layer	
8 inches of lithic sand and fragments mixed with humus	1790 to 12-K
1 inch of pumice mixed with humus	9-K
15 inches of vitric shards and ash	8-K to 1-K

In the desert, 6 miles to the southwest of Kilauea, at the locality of the human footprints, there remain patches of two pisolitic layers, probably representing beds of original deposition, and much wind-transported, dune sand. One section showed:

	Inches
Shifting dune sand	6
Crusted stony pisolite layer	2
Imprisoned dune sand	36
Mud-cracked pisolitic layer	2
Imprisoned dune sand	48
Pahoehoe lava surface	

The lower pisolitic bed is made up of three layers: at the bottom is half an inch of finely laminated dust, next an inch of pisolitic dust, and on top is another half an inch of finely laminated dust (Plate 3B). The surface of this bed is cut by mud cracks which extend down part way into the pisolitic layer. The cracks have been filled with fine drifted dust. In the surface of the layer are found some of the fossil footprints, impressed even into the middle of the central pisolitic layer. The whole bed has been consolidated enough to resist immediate removal by wind and rain, but it has been and is being removed slowly by erosion. In many places all of the upper laminated dust and the middle pisolitic layers have been removed, leaving only a thin crust of the lower, laminated, dust layer. In the section described above, a trench was driven into the bank exposing a 10-foot section containing the two footprint-bearing pisolitic beds with dune sand between. In this 10-foot artificial exposure, the lower bed ranged in thickness from 2 inches to half an inch in places where wind scour had removed the upper two-thirds of the bed prior to its burial by the dune sand.

The upper footprint bed consists of mixed sand, lithic fragments (up to a half inch in diameter), and pisolitic dust and ranges in thickness from 1.5 to 2 inches. Its surface is protected by a thin crust, and the entire layer is partly consolidated. The scattered remnants of this deposit in the footprint area have not yet been traced with any assurance into the continuous layers nearer the crater which can be correlated with eruptions with some confidence. It appears reasonable to assign the upper, crusted footprint layer to the 1790 eruption, chiefly because it is the youngest and because it is associated with the known presence of Hawaiians in the area during the eruption. On the other hand, it might be argued that the two pisolitic layers should be correlated with the two phreatic eruptions which made the thickest deposits remnant on the southwest rim near the crater, namely the seventeenth and fifteenth eruptions. Possibly more detailed field work may yield data on which a definite correlation may be based. At present, it seems certain that the two footprint-bearing layers are products of

two different phreatic eruptions which probably should be chosen from among the 1790, the seventeenth, and the fifteenth eruptions.

Evaluation of the time span covered by the eruptions of the Keanakakoi formation can be no better than a guess at present; but perhaps a guess, tempered by the impressions of relative time intervals and periods of exposure that one gets while "living with the problem" in the field, is worth recording.

The present forest cover on the northeast rim of Kilauea is probably the heaviest tree growth which has developed in any period since the emplacement of the upper lava flow of this part of the crater rim. The deposits of the 1790 and the eighteenth eruption on this part of the rim are too light to have killed well-established trees, though each probably killed small ground-covering vegetation. Deposits from the seventeenth eruption were thick enough probably to have killed all vegetation as far as half a mile to the northeast of the rim. Judging from comments of early visitors, a good ground cover and at least a scattered stand of scrubby ohia were established on the immediate rim as long ago as 1825. Taking everything into consideration, my impression is that the present reforestation of the rim since the seventeenth eruption has required approximately 400 years. The next heaviest vegetative cover formed on the northeast rim was established in the time interval between the twelfth and the seventeenth eruptions. The humus layer indicates heavy ground cover, and molds of small ohia trees have been found. The "kill" of the twelfth eruption probably extended about the same distance to the northeast of the rim as did that of the seventeenth. This time interval may have been about 300 years. Much less time seems to be required for the intervals between the ninth and the twelfth, and the fifth and the ninth eruptions, since the humus is thin. The vegetative cover developed on the deposits of the fourth eruption consisted largely of fern, ohelo, and other low growth and probably could have developed in about 200 years. A similar period apparently would suffice for the time between the second and third eruptions. An estimate of perhaps 1,500 years is suggested for the total time covering the explosive eruptions of the Keanakakoi formation.

CONCLUSIONS

Detailed study of the disconformities and unconformities between the beds in the pyroclastic deposits of Kilauea crater and appraisal of the relative time intervals which they represent, combined with study of the lithology of the beds, have facilitated a preliminary catalog-

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PLATE 1A. Abrupt transition from heavy forest cover to barren surface, possibly the southeast limit of "forest kill" by the 1790 eruption, perpetuated because local climatic conditions have inhibited reforestation. Looking northeast across Keanakakoi Crater (foreground) and the east end of Kilauea (left background) from locality P. Photograph by H. A. Powers, September, 1947.

PLATE 1B. Remnant of the mantle of 1924 bedded lithic ash, originally plus 5 inches thick, as exposed by the small excavation in the foreground. This area is subject to torrential rains, but the absence of an incised drainage net indicates that runoff erosion is subordinate in effectiveness to wind planation and undercutting. The present surface is planed across the bedding of 1924 ash at a low angle, and a desert pavement of residual larger fragments is beginning to accumulate. Photograph by H. A. Powers, September, 1947, at locality M.

PLATE 1C. Remnant of 1924 ash, originally plus 3 inches thick in this area, showing results of wind erosion by undercutting along least resistant layers. Most of the remaining patches of the 1924 ash mantle are in slight surface depressions where moisture persists longer than on the adjacent slopes, perhaps retarding removal of the patches by wind erosion. Photograph by H. A. Powers, September, 1947, at locality N.

PLATE 1D. Keanakakoi formation pyroclastics mantling the inner face of the southwest wall of Kilauea Crater exposed by a short inflowing ephemeral stream. The bedded vitric deposits of the third and fourth eruptions (lower left) are truncated by an erosion surface equivalent to a good humus layer on the humid northeast crater rim. On the unconformity are the bedded vitric deposits of the fifth to the ninth eruptions (center and right center). The upper beds represent the seventeenth to 1790 eruptions mantling a major erosion surface from which all deposits of the tenth to the sixteenth eruptions have been removed. Photograph by H. A. Powers, September, 1947, at locality T.

PLATE 1A

PLATE 1B

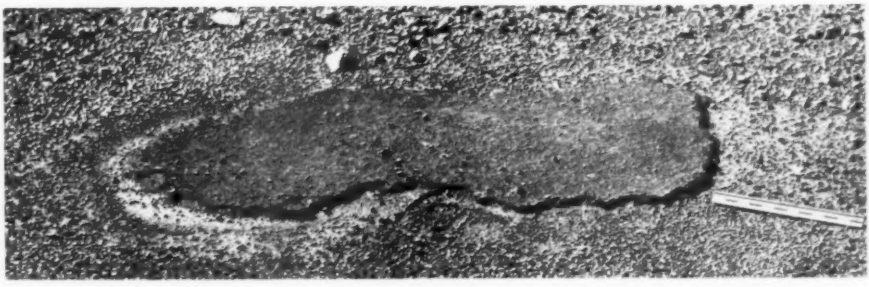

PLATE 1C

PLATE 1D

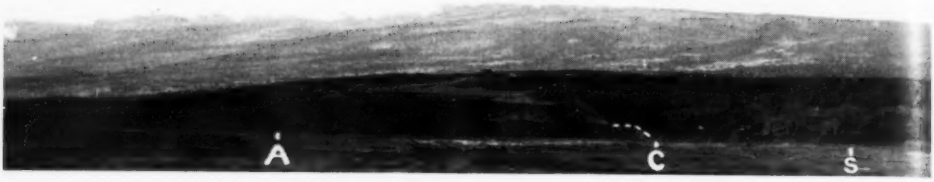

PLATE 2A. Northwest wall of Kilauea Crater seen from near Keanakakoi. The Uwekahuna tuff formerly was exposed at A, and at present is exposed at C and S. The rim block containing A has slumped a greater amount from its original elevation than has the rim block containing C and S. Photograph by H. A. Powers, September, 1947.

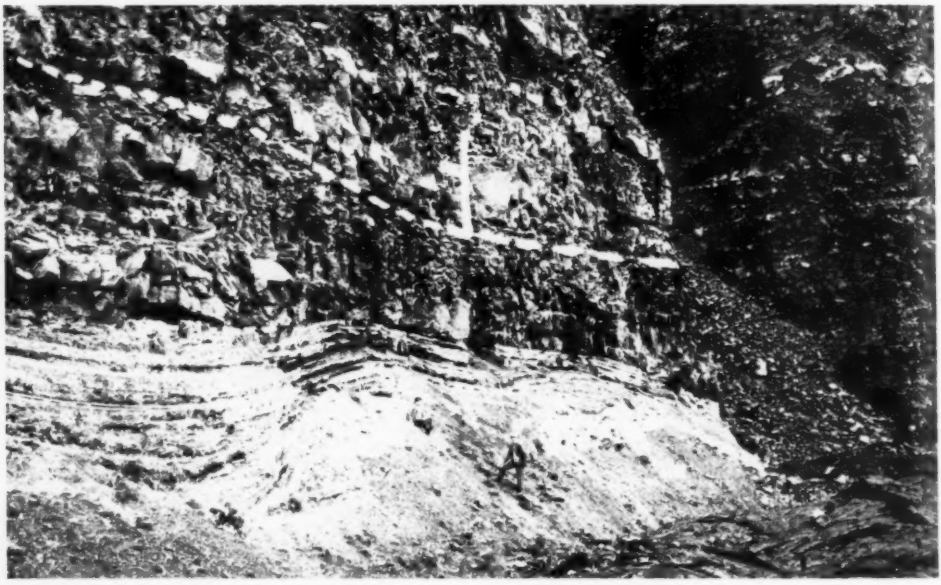

PLATE 2B. Bedded Uwekahuna tuff at locality A buried by the 1919 pahoehoe flow on the crater floor which filled against the cliff as high as the dashed line. Vertical solid line indicates the span of a 13-foot surveyor's rod located against points of the cliff face which have not changed since the photograph was taken by T. A. Jaggar, July, 1913.

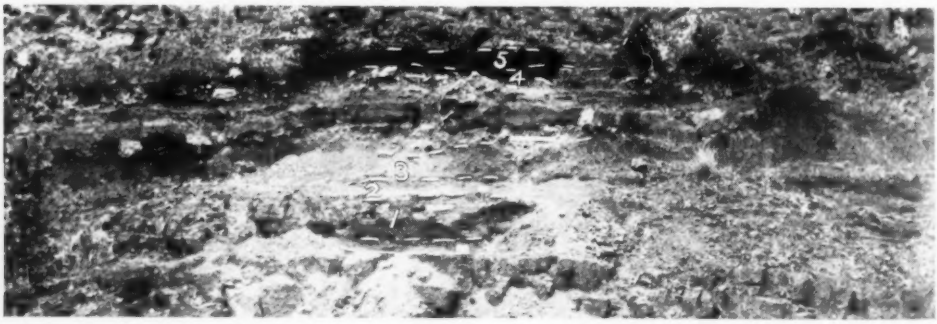

PLATE 2C. Uwekahuna tuff, 3½ feet deep, lying on the basal pahoehoe flow exposed in the cliff at S. Base of tuff is 5 feet above the present crater floor. Inter-eruption surfaces have been spotted on the negative. Photograph by H. A. Powers, September, 1947.

PLATE 3A. Kilauea, northwest crater wall, seen from Keanakakoi, in which Uwekahuna tuff crops out a few feet above the crater floor between talus fans from C to B. Photograph by H. A. Powers, September, 1947.

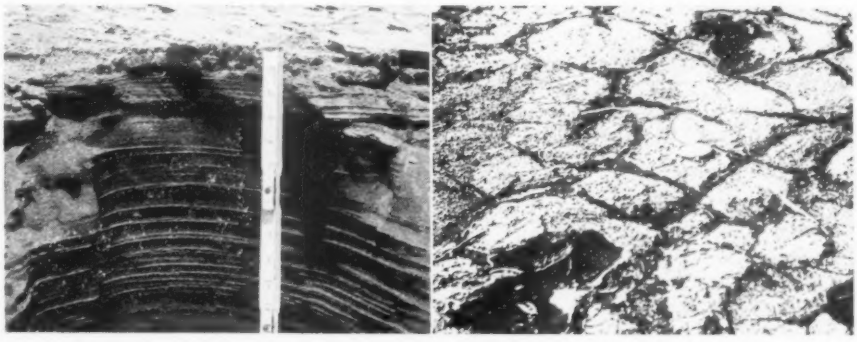

PLATE 3B. Lower mud-cracked stratum retaining human footprints, lying on bedded dune sand about 6 miles southwest of Kilauea. Photograph of footprints by T. A. Jaggar, July, 1921; of vertical section by H. A. Powers, August, 1931.

PLATE 3C. Upper crusted stratum of stony pisolite retaining human footprints in the same locality. Photograph by T. A. Jaggar, July, 1921.

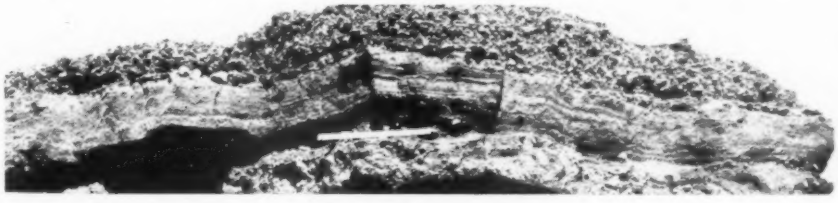

PLATE 3D. Pumice of about 1815 bedded on remnants of 1790 gravel not exceeding an inch in thickness, lying on pre-1790 stony pisolite. Below the 12-inch rule is the pisolitic agglomerate of the fifteenth phreatic eruption. Photograph by H. A. Powers, September, 1947, at locality W.

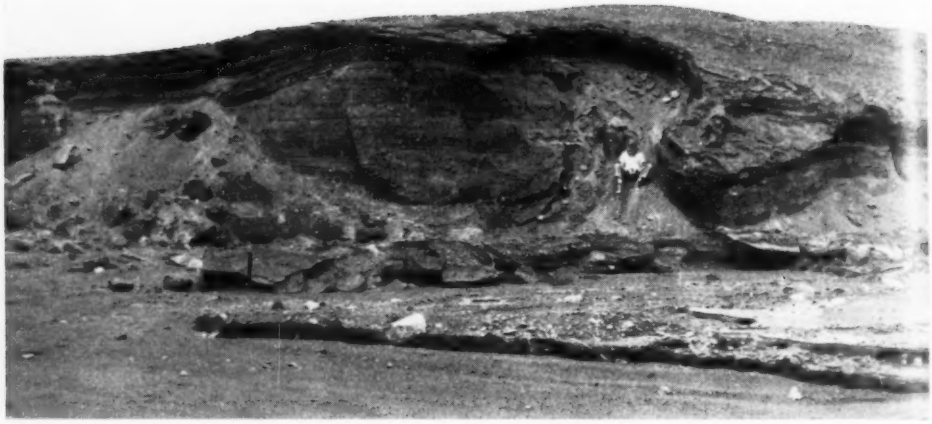

PLATE 4A

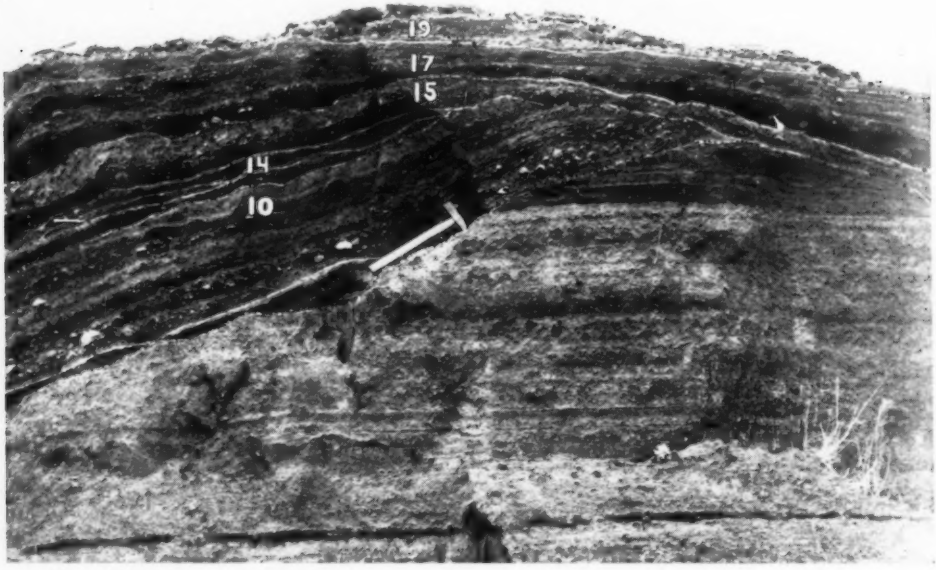

PLATE 4B

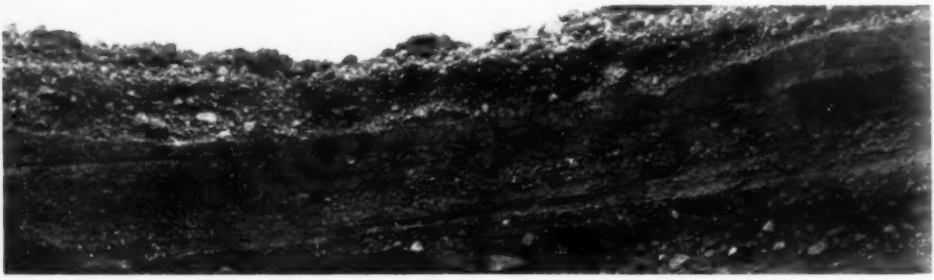

PLATE 4C

ing of at least 26 separate explosive eruptions of Kilauea. Each eruption appears to have been caused either by phreatic or by magmatic explosions; no single eruption seems to require both phreatic and magmatic explosions to account for the lithologic constituents in its deposit.

The Uwekahuna formation seems to have been deposited on the floor and outer slopes of an earlier caldera by at least five magmatic eruptions separated by appreciable time intervals.

The Keanakakoi formation seems to represent at least 10 phreatic and 11 magmatic eruptions which have occurred since the last major overflows of lava which form the present crater rim.

Details of distribution of the Keanakakoi deposits promise to be useful in working out the details of the late structural history of Kilauea. For example, the slumped rim blocks in the northeast corner carry the thickest deposit from eruption number 2-K, suggesting early collapse of these blocks; and most of the deposits on Byron's Ledge are not appreciably thicker than those on the adjacent southeast rim, which is 100 feet higher. Perhaps this indicates a late date for the collapse of Byron's Ledge.

The study of the early Keanakakoi magmatic explosion deposits has a direct bearing on the problem of the contribution of the Kilauea summit crater to the older Pahala ash formation of Hilina Pali and other areas 10 miles or more distant from the summit crater.

The chronological table of explosive eruptions may conceivably be useful as an actual time scale when coupled with results from studies of rate of reforestation. The most mature forest east and north of Kilauea Iki apparently was never killed by any explosive eruption during the Keanakakoi time and thus may represent uninterrupted encroachment from the slope of Mauna Loa as much as 5 miles distant across the surface of the last rim overflow of Kilauea. A less mature forest extending from the crater rim to about a mile northeast of the rim may represent the total development of vegetation since the seventeenth eruption, which probably killed all vegetation to that distance. The growth immediately on the northeast rim may represent the recovery from a partial kill of vegetation in 1790.

The general picture sketched in by this study suggests these long-period fluctuations in the intensity of lava pressure:

(1) pre-Uwekahuna, high-pressure, dome-building phase

(2) low-pressure collapse and explosive eruptions of Uwekahuna tuff

(3) high-pressure, post-Uwekahuna resumption of dome-building

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PLATE 4A. Keanakakoi pyroclastics on the outer slope of the southwest Kilauea rim. Deposits of the fifteenth, seventeenth, eighteenth, and 1790 eruptions mantle an erosion surface which truncates beds of the fourteenth to the tenth eruptions. The erosion surface marked by the hammer truncates the vitric ash of eruptions earlier than the tenth. Details of the section in upper left center show in Plate 4B, and details of the upper beds at the head of the re-entrant behind the figure show in Plate 4C.

PLATE 4B. Remnants of two layers of 1790 gravels, separated by a depositional break, lie on a desert surface truncating the stony pisolite of the eighteenth eruption. Erosion surfaces have been emphasized by retouching on the negative. Beds from the seventeenth eruption reach 8 inches in thickness at the right of the section and lie on the eroded surface of beds from the fifteenth eruption, the lowest layer which is continuous across the face of the section. A lens of pumice from the thirteenth eruption (marked by pocket knife at left) lies between remnant patches of beds from the fourteenth and twelfth eruptions. The vitric deposits from the third and fourth eruptions lie beneath the horizontal desert surface (not retouched), which extends across the photograph just below the grass clump on the right.

PLATE 4C. Gravel of 1790, from 4 to 6 inches thick, lying on the eroded layer of stony pisolitic mud from the eighteenth eruption, originally 3 inches thick in this section. Erosion occurred after consolidation of the pisolitic mud, as it truncates the bedding within the layer, and has cut the bed to a remnant 1 inch thick in the photograph. Beneath the stony pisolite layer is a desert surface eroded on deposits from the seventeenth eruption about 10 inches thick including the basal layer of coarsest fragments.

Photographs by H. A. Powers, September, 1947, at locality U.

(4) low-pressure collapse of present caldera
   (*a*) partial collapse and early Keanakakoi magmatic explosions
   (*b*) severe collapse and phreatic explosions reaching a maximum in the fifteenth and seventeenth eruptions

(5) possible gradual resumption of high-pressure dome-building suggested by the important crater-filling activity since 1790

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The Origin of the Native Flora of Polynesia[1]

EDWIN BINGHAM COPELAND[2]

MY INVITATION to this symposium states that "It is desirable that a man should report on his own research, but no speaker should feel confined to this range. What we want is an evaluation of recent research in each field as it has come from or applies to the Pacific Basin, and then the speaker's own estimate of whither this may be leading."

My own research has been restricted to the ferns. If the Philippines be within the field of interest, this research has covered a period of 44 years. Twenty years ago, on the invitation of the Bishop Museum, I prepared and published in their bulletin series a fern flora of Fiji. A few years later, I did the same for the Society Islands. Comparing these two groups of islands, it was evident that their ferns had migrated eastward. Their common ferns are mostly common farther west, even as far away as Malaya, and their endemics are derived from these common, wide-ranging species.

The conclusion that the ferns of Polynesia were immigrants from the Malay region was at that time almost inevitable. It is old and reasonable dogma that evolution, in a large way, takes place on continents, and that islands draw thence their population. So, Asia, which used to include the Sunda Islands, seemed the natural source of the flora of the neighboring islands to the East—Celebes, and then New Guinea, and thence the Solomons, and Polynesia, and New Caledonia, and New Zealand.

This interpretation of nature was supported by a mental aberration: The flora of Java was the first in this part of the world to be well known, and when we found in the Philippines a plant already known in Java, we simply assumed Javan origin. We used to speculate on the route of immigration, and to be surprised that this route seemed to be by Celebes oftener than by Borneo.

There were items which ought to have disturbed our confidence. For instance, a considerable number of species in the highland of Northern Luzon are common to China and even to the Himalayas. On the map, this looks like the beginning of a route from the continent to Polynesia; and men have migrated eastward from the Philippines. But not one of the plants in question reaches even to Southern Luzon.

My eyes were opened when, beginning some sixteen years ago, I made a monographic study of the family Hymenophyllaceae, the filmy ferns. Contrary to anticipation, or even suspicion, this study led me unescapably to the conclusion that this family is entirely of Antarctic origin. I abstain from presenting the detailed evidence for this conclusion, because it has already been digested and published (Copeland, 1938). It is as positive as it will be when illustrated by fossil evidence—of which the first item, from the island Chiloe, reached me in May of this year.

The Antarctic origin of Hymenophyllaceae being positively established, it struck me that it would be very strange if some or many other ferns did not have a similar history. This was already recognized for a few genera and species, which were regarded as remarkable in this respect. A comprehensive study of distribution showed me at once that these were not in reality exceptional cases, but were the con-

[1] Read by invitation to the Pacific Section, A.A.A.S., at San Diego, June 17, 1947.

[2] Research associate in botany, University of California, Berkeley, California. Manuscript received April 22, 1948.

spicuous examples of a general rule—that not less than half of all ferns were of Antarctic ancestry. Before I was ready to publish, this figure grew to three-quarters; and I have more recently raised it to 90 per cent. These figures apply to the ferns of the world. Except for a possible half-dozen Hawaiian species of freakishly scattered apparent geographic affinity, there is not one of the ferns of the Pacific islands which I do not now regard as of reasonably direct Antarctic origin.

Let me presume to hammer this home, because, as to the ferns, I speak with some authority. Contrary to our old ideas, the rich fern flora of Malaya was not the source of Polynesian ferns—not of one Polynesian fern. For it to have been so, the sun would have had to rise in the west. New Guinea is richer in ferns, the richest land in the world, and is the immediate source of the most of the ferns of the Philippines, Malaya, and southeastern Asia. For a brief period, clinging to a fragment of earlier prejudice, I pictured Polynesia as likewise populated from New Guinea; but this is not so likely.

Fiji is a plausible center of radiation of Polynesian ferns. I do not believe that it received its ferns directly from New Guinea, but it may have done so from somewhere along the path of northward migration—from the general region of the New Hebrides, as a suggestion. Eastward migration in these latitudes is against the prevailing wind and against the direction of storms, which explains the rapid drop in population from Fiji to Tahiti, and eastward in general.

Only Rapa among oceanic islands shows some indication of having any ferns not of ultimate New Zealand origin. If Juan Fernandez and the Galapagos are included in the subject of discussion, their ferns are of either direct Antarctic (as to some of the ferns of Juan Fernandez), or American origin—ultimately Antarctic, but by way of Graham Land and Tierra del Fuego. Almost all Hawaiian ferns are derived ultimately from New Zealand.

So much for the ferns, about which I speak from personal knowledge. It is unthinkable that what occurred with ferns should not have happened with other plants, to the extent that there was a source of supply in Antarctica, and at least as far as they depend upon the wind for dissemination.

Doctor Hooker's original postulate of an Antarctic origin of austral floras was based on his observation of the distribution of flowering plants (Hooker, 1860). Skottsberg, 30 years ago (1915: 142), published a list of plants common to New Zealand and sub-Antarctic America, and without a plausible northern source. This list includes representatives of 49 families, including Leguminosae, Compositae, Rubiaceae, sedges and grasses. As to the species on Skottsberg's list, Antarctic origin is little less than certain. Polynesian plants, even if common to New Zealand, were excluded from that list. For today's purposes, they should of course be included. If they and their immediate relatives, presumably of more recent evolution, be included, a list thus compiled will include more than half of the flowering plants of Polynesia. At this point, my conclusion is that all Polynesian ferns and more than half of Polynesian flowering plants are of ultimate Antarctic ancestry.

For the most of the remainder of the flowering plants, no other ancestry or origin can be postulated with greater plausibility. The situation as to them is simply that the evidence has not yet been discovered, or is not yet digested and understood. There are no important families of flowering plants except Myrtaceae (regarding Proteaceae as relatively unimportant) for which a nearly completely austral origin can be affirmed with the same confidence as for the ferns. I suspect all Polynesian Rubiaceae of Antarctic origin; also, excepting a few ubiquists, all Cyperaceae and Gramineae.

As is true of ferns, the "flowering floras" of Polynesia and Malaya have much in common, and the time has been when men could conclude therefore that the poorer flora of Polynesia was

derived from the comparatively rich flora of Malaya. Today, it is more generally recognized that the better explanation is that the two floras have a common origin of their common elements, and New Guinea is looked to for the common source. But again, taking a lesson from the ferns, and bearing in mind the difficulty of direct eastward migration, it seems more reasonable to look for a common outside source than to suppose that one area was colonized from the other. To the extent that this common flora is of ultimate austral origin, it would have had to back-track to the Solomons and New Hebrides before entering Polynesia, and to do this against the winds and the oceanic currents; I cannot believe that on any major scale this ever happened. So, of present land areas, I regard New Caledonia and the New Hebrides as the roughly approximate region from which Fiji and thence Polynesia received the bulk of their vegetation.

Some such history as I propose has been rejected by some very respectable authorities. Thus Diels, in the Setchell Festschrift (1936: 191), treating of groups of plants of distinctively austral occurrence, wrote that "it is impossible to infer that they originated in the south." This is evidently not true, because I do so infer, and so have Hooker, and Christ (1910: 248), and Skottsberg, and still others.

More disquieting to me, and not so summarily to be dismissed, is Merrill's recent (1945) statement: "It has also been suggested that scattered throughout this vast region are certain types that were apparently derived from ancient Antarctica. But this idea is purely theoretical and is one that can scarcely be proved." As I am expounding this theoretical and scarcely provable idea, I must of course concede that direct proof is impossible. But other proof can carry conviction. A frog in the milk pail is not direct proof that the milk has been diluted. None of us has seen any plant emigrate from Antarctica, and no plants are now so emigrating. In the absence of direct evidence, the indirect evidence by present distribution, coupled with the fact, unknown to Hooker and to Christ, that Antarctica was at a definite and not too remote past time a fit place for plants, is the nearest possible approach to direct proof that they did migrate thence, into and across temperate lands.

Although migration from Antarctica has long ceased (the last warm era there was Miocene, say twenty million years ago), I suppose that it goes on now along the old paths where the climate now permits. Because Merrill has provided dependable figures on the distribution of species, I will use them to show how this migration seems to have occurred more recently in two families, Elaeocarpaceae and Orchidaceae.

The pertinent figures on the occurrence of species of *Elaeocarpus* are:

New Guinea	114
Philippines	49
Borneo	40
Java	18
New Caledonia	30
Fiji	12
Samoa	6
Rarotonga	1
Hawaii	1

Merrill concludes, in harmony with general practice, that New Guinea is the focus of distribution. As to all lands farther west, I read his evidence in the same way. As to the rapid decrease in number of species from group to group in Polynesia, his figures agree with the evidence of the ferns in showing the great difficulty of eastward migration in this region. But his figure of 30 species in New Caledonia is very significant to me. New Caledonia has one-fortieth of the area of New Guinea, but has more than one-fourth as many species of *Elaeocarpus*. The winds and the currents are always from New Caledonia to New Guinea, and I find it hard to doubt that this is the direction of migration. The genus is of minor importance in Polynesia, but what species there are seem most probably to have come from the west or southwest, not from the northwest, not from New Guinea.

As to the orchids, now regarded as the largest family of plants, Merrill presents these figures on the number of species:

New Guinea	2,000
Philippines	900
Fiji	125
Tahiti	30
Marquesas	4
Hawaii	3

New Zealand has 66 species, and an old figure (Hooker's) for Tasmania is 74—large enough to point strongly to Antarctic origin.

The overwhelming mass of tropical orchids are epiphytes. I have compiled no figures, but am advised that in the Philippines, and in all that part of the world, the ratio of epiphytes to terrestrial species is more nearly ten to one than five to one. In New Zealand, there are 7 epiphytes and 59 terrestrial species; in Tasmania, 1 epiphyte and 73 terrestrial species. The paucity of epiphytes in the far south may be explained by the climate. But Polynesia is tropical. Its ratio of epiphytic to terrestrial orchids is about three to one—not more than half of what should be expected if colonization had been from New Guinea. The obvious conclusion seems to be that it was colonized from farther south, and that adaptation to tropical conditions remains incomplete.

Conclusion: The ferns, and a considerable part of the flowering plants, of Polynesia are of austral origin. As to the bulk of the flowering plants, I cannot claim, against Merrill's recently published judgment, that the present tendency of thought is in support of my views, but have shown that some of his detailed figures do support them.

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NOTES

On the Herding of Prey and the Schooling of the Black Skipjack, *Euthynnus yaito* Kishinouye

WHILE PARTICIPATING IN the Bikini Scientific Resurvey in the northern Marshall Islands in the summer of 1947, the authors observed three medium-sized black skipjack (*Euthynnus yaito* Kishinouye) herding a closely packed school of several hundred scads (*Decapterus sanctae-helenae* (Cuvier)) over a large coral head in Rongerik lagoon. For fully a 3-hour period the aquatic life on and about this coral head was studied by use of the skin-diving technique, and during this time this unusual group passed back and forth frequently, apparently unconcerned about our presence. Since Kishinouye's reference to such herding activity by tuna (*Tokyo Imp. Univ., Col. Agr. Jour.* 8(3): 382, 459, 1923) is couched in generalities, and since our observations on the black skipjack are contrary to statements made by this author, we place these underwater observations on record to clarify several moot points in the feeding and schooling habits of this species.

The predilection of these pelagic fish for this coral head is understandable on the basis of the part such coral heads play in the general ecological features of a lagoon in the Marshalls. The coral head, typical of many, rose about 75 feet from the lagoon floor to approximately 25 feet below the surface of the water. It was roughly circular, about 75 yards across, with a rather steep talus slope forming its sides. The surface of the mound was covered with sand and larger coral fragments, interspersed with groups of living corals of numerous species and sparse patches of algae. Ecologically such coral heads seem to occupy a physical niche comparable to an oasis on land, as each supports a more luxuriant growth of organisms than does the surrounding terrain. Numerous species of common coral fish, several medium-sized carnivorous fish, and many plankton-feeding fish habitually remain on and about these mounds. Thus the elements essential to food chains are more or less isolated in the vicinity of these coral heads, and there both scads and some species of tuna habitually forage. The fact that these conditions prevail afforded us an opportunity for repeated observations upon these pelagic species from a unique vantage point.

The three tuna usually followed the school of scads rather closely, with one tuna at each rear flank of the school and the third lagging behind them. Now and then the scads would turn off to one side, at which time the tuna on that side would move forward swiftly and herd them back into line. It became obvious that the school of scads was prevented from leaving the area over the top of the coral head, being herded back whenever it moved over deep water. On one occasion a laggard scad was swiftly picked off by the rearmost black skipjack; however, except for this incident the tuna made no attempt to prey upon the scads during our period of observation. Scads are uncommon in the lagoons in the northern Marshalls and probably do not constitute a large proportion of the diet of this species of tuna. Studies made by Jack Marr and Osgood Smith of the U. S. Fish and Wildlife Service (unpublished data) on the food habits of 33 black skipjack caught outside of the lagoons failed to show any scads in the diet of this species. Scads were most frequently encountered in the stomachs of the dog-tooth tuna (*Gymnosarda nuda* Kishinouye) which ranges in the same area.

In his report on tuna herding prey, Kishinouye (*op. cit.:* 382) states: "Bonitos, except *Euthynnus yaito*, are said to be very clever in making a school of small fish very dense, by swimming around the school of the victims, and devouring stray or forlorn individuals gradually. On the contrary, tunnies and seerfishes swim into a school of victims, and disperse them. The feeding of fish seems not always the same throughout the year. The striped bonito is said to decline to take bait in certain seasons, generally in midsummer." In his discussion of the food and feeding habits of the black skipjack, Kishinouye (*op. cit.:* 459) says that the species

is voracious and that it feeds primarily on small fish and medium-sized plankton. He also describes their feeding method, whereby they dart swiftly into a school of small fish and scatter them in the same manner as do the pelamids and tunas. Our observations on the feeding methods of the black skipjack certainly do not coincide with those set forth by Kishinouye. However, it is entirely possible, as he states, that the feeding habits of the black skipjack may vary throughout the year. Undoubtedly their habits vary depending upon the type of food available at any particular time of the year.

Kishinouye also implies that *Euthynnus yaito* is usually a solitary fish and is not found in schools. Schools of this species, ranging from a few fish to many hundreds or even thousands of individuals, are often seen around the Hawaiian Islands throughout the year; and, during the summers of 1946 and 1947, very large schools of this species were common in the northern Marshalls. It is quite likely that such schools exist in the Marshalls throughout the year; except for the summer months, however, no observations have been made. Chapman (*Calif. Fish and Game*, 32(4): 165–170, 1946) states that black skipjack were present in large schools at Midway Island, Johnston Island, and Palmyra Island in the fall of 1943. Most of the observations reported by Kishinouye were made at the periphery of the range of *Euthynnus yaito;* in this region smaller schools and perhaps even solitary individuals would more or less be expected.

The only observations on the herding of prey by fish other than the tuna or tuna-like fish were reported by Gudger (*Carnegie Inst. Wash., Pub.* 252: 75–76, 1918), who cites three instances involving the great barracuda, *Sphyraena barracuda* (Walbaum). In each case only a single barracuda was concerned; but since this species is rather solitary, it would have been rare indeed to see it engaged in a co-operative effort. In two cases the prey was herded into very shallow water; in the other instance the small fish remained around piles and swam among the rocks, not attempting to escape. In none of these observations on barracuda did the process of herding seem to be so well defined or so efficiently accomplished as it was in the relationship of the black skipjack to the scads. Of great significance was the fact that these skipjack were engaged in a co-operative effort.— *Robert W. Hiatt, Department of Zoology and Entomology, University of Hawaii, and Vernon E. Brock, Division of Fish and Game, Territorial Board of Agriculture and Forestry, Honolulu, Hawaii. Published by permission of Chief of Staff, Armed Forces Special Weapons Project, National Military Establishment.*

An Addition to the Fish Fauna of the Hawaiian Islands

SPENCER TINKER, Director of the Waikiki Aquarium, called the writer's attention to a large and showy chaetodontid which he had added to the aquarium collection as a species unknown to him and to local fishermen. This species was readily identified as *Pomacanthodes imperator* (Bloch), heretofore not reported from Hawaiian waters. *P. imperator* is a reef dweller characteristic of the Indo-Australian faunal region of which Hawaii stands as the northeastern frontier; hence, upon faunal grounds, the occurrence of the species in Hawaii is not inexplicable. However, in view of the intensive shoal water fisheries in the Hawaiian area together with the volume of ichthyological collecting and observing that have occurred here in the past, it would appear that the species is very rare in local waters.

This specimen, 198 mm. in total length, was taken on January 10, 1948, in 15 fathoms of water by a trap fisherman off Ewa, Oahu. The fish, which was injured in the trap, died on January 13, 1948, and is presently preserved in the fish collection at the University of Hawaii Marine Laboratory at Waikiki. — *Vernon E. Brock, Director, Division of Fish and Game, Territorial Board of Agriculture and Forestry, Honolulu, Hawaii.*

United States Committee on the Oceanography of the Pacific

THE FIRST MEETING of the United States Committee on the Oceanography of the Pacific was held on June 19 and 20, 1948, at the California Academy of Sciences, San Francisco, California. This committee was established in 1947 by the National Research Council through the Pacific Science Board to replace the former American National Committee on the Oceanography of the Pacific. Members of the reconstituted committee are Thomas G. Thompson (chairman), Director of the Oceanographic Laboratories, University of Washington; Richard H. Fleming, Chief, Oceanographic Division, Hydrographic Office, Department of the Navy, Washington, D.C.; Robert C. Miller, Director, California Academy of Sciences, San Francisco; Charles J. Fish, Supervisor, Pacific Oceanic Biology Project, Oceanographic Institution, Woods Hole; Oscar E. Sette, Director, Pacific Oceanic Fishery Investigation, U. S. Fish and Wildlife Service, University of Hawaii, Honolulu; Roger Revelle, Associate Director, Scripps Institution of Oceanography, La Jolla; and Robert W. Hiatt, Chairman, Department of Zoology and Entomology, University of Hawaii, Honolulu. Harold J. Coolidge, Executive Secretary of the Pacific Science Board, met with the Committee.

The organization of American participation in oceanography and marine biology at the Seventh Pacific Science Congress to be held in New Zealand during February, 1949, occupied most of the agenda. It was decided that presentations at the Congress should be classified in three categories: (1) over-all reports covering the decade since the last Congress, (2) local regional programs, and (3) the high seas Pacific Basin program. Suitable titles covering these phases were formulated and scientists active in the various fields were asked to prepare papers for presentation at New Zealand. Two symposia, one concerning conservation of marine resources and the other involving marine biogeographical provinces in the Pacific Basin, were recommended for inclusion in the program.

A second topic on the agenda dealt with the need for standardization of gear and methods, and methods and arrangements for correlation and integration of programs involving the oceanography of the North Pacific Basin. Since the absence of Japanese scientists from the New Zealand Congress precludes the possibility of considering these items in detail, it was deemed advisable to hold a conference on this subject after the Congress at a time when investigators from all nations who would participate in oceanographic research in the North Pacific Basin would be able to attend. A subcommittee composed of Charles J. Fish (chairman), Robert W. Hiatt, and William C. Herrington was appointed to consider the matter.

Continuation of the work between Congresses was considered highly desirable, and to this end a recommendation will be made to the Science Congress that each country appoint a representative to serve as a member of a "Standing Committee on Oceanography." It is hoped that implementation of suggestions for co-ordinated work made at each Congress will be facilitated through such special channels.

A special report by R. W. Hiatt on the development of the Hawaiian oceanographic research and training program in relation to the establishment of the Hawaii Marine Laboratory and the initiation of the vast program of research on tunas undertaken by the U. S. Fish and Wildlife Service was presented. Plans have been formulated or are being formulated for cooperation with several mainland institutions including the University of California and the Woods Hole Oceanographic Institution. C. J. Fish reported on the progress of the Pacific Oceanic Biology Project which was created by the Office of Naval Research upon recommendation of the Pacific Science Conference and is being carried out under contract with the Woods Hole Oceanographic Institution. Plans being developed for continuation after September, 1948, emphasize training of oceanic biologists who are needed before field work can begin. Arrangements have been made with Rhode Island State College and its Narragansett Marine Laboratory to provide academic training and field experience for graduate students prior to their assignment for study under specialists at Woods Hole. Close co-operation with the U. S. Fish and Wildlife Service and the Hawaiian training program will be maintained.—R.W.H.

The Pacific Oceanic Fishery Investigation

ON JULY 1, 1948, the sum of $1,000,000 became available to the U. S. Fish and Wildlife Service, through Congressional appropriation. This sum will implement H.R. 859 (known widely as the Farrington Fisheries Program) which provides "... for the exploration, investigation, development and maintenance of the fishing resources; and development of the high seas fishing industry of the territories and island possessions of the United States in the tropical and subtropical Pacific Ocean and intervening seas." The bill authorizes the U. S. Fish and Wildlife Service to secure laboratories, vessels, and personnel to investigate the biologic, technologic, and economic problems concerning the tunas and tuna-like fishes. Oscar E. Sette, former Chief, South Pacific Investigations of the U. S. Fish and Wildlife Service with headquarters at Stanford University, has been appointed director of this vast program. A new laboratory and administrative headquarters will be constructed on the campus of the University of Hawaii. Berthing facilities and warehouse space have been secured at Pearl Harbor. Although plans have not been completely formulated at this writing, an extensive oceanographic investigation will parallel the fishing operations. Additional personnel in the fields of ichthyology and fisheries biology have been added to the University staff to provide undergraduate and graduate curriculums designed to train ichthyologists, fisheries biologists, and oceanographers for work of this type in the Pacific. Close cooperation between the staff of the Fish and Wildlife Service laboratory and the staff of the University will be maintained to provide the best theoretical and applied training for students at all academic levels.—R.W.H.

Western Regional Conference for UNESCO

THE REGIONAL CONFERENCE for UNESCO (United Nations Educational, Scientific and Cultural Organization) held at San Francisco, May 13–15, 1948, was attended by nearly 3,000 delegates from eight western states, Hawaii, and Alaska. The delegates represented many different types of organizations. Some, probably a small minority, were delegates from states or territories and represented the local chapters of national scientific organizations by request of the national officers.

At the opening plenary session the aim of UNESCO was stated to be the prevention of war. A great many scientists in attendance were startled by the abruptness and simplicity of this statement. Many delegates, acquainted with some of the work already done by UNESCO in aiding the restoration of libraries, exchange of technical and cultural literature, and the like, had conceived UNESCO to be a specialized segment in the United Nations pattern but were not prepared for the phraseology of wide, popular appeal, nor for the subsequent extremely general discussions, dealing with various aspects of internationalism in relation to people, which were lacking in any working approach to the business of particular fields of endeavor on the international level.

While it was for many scientists a stimulating experience to attend such a meeting as citizens, it may well be queried to what extent representation from various specialized scientific organizations will be sustained unless some prepared opportunity is afforded for conferences on problems of international scientific liaison and collaboration.—C.K.W.

News Notes

The Pacific War Memorial announces the establishment of a Memorial Research Field Station on Koror Island, Palau Archipelago. The former Japanese meteorological station has been turned over to the Memorial by the Navy Department. This building is of poured concrete, with a penthouse. Electric power is available.

The Memorial is anxious to make the facilities available for use by qualified scientists as soon as possible. By agreement with the War Memorial the Navy Department will provide transportation for qualified Pacific War Memorial personnel.

Inquiries concerning use of the station should be addressed to: Pacific War Memorial, 44 West 50th Street, New York, N.Y.

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Insects of Hawaii.—This inclusive treatment of the insect fauna of the Hawaiian Archipelago is being written by Elwood C. Zimmerman, Associate Entomologist, Experiment Station, Hawaiian Sugar Planters' Association, and Curator of Entomology, Bernice P. Bishop Museum, Honolulu. The first five volumes of a probable 12 to 15 total have been completed. Volume 1 was released July 27, the remaining four volumes will be available during the summer and fall. While this is a treatment of the insects of Hawaii, it will be extremely useful throughout the entire Pacific Area.

Volume 1, which is introductory, covers the geological history of the Archipelago and various phases of the origin and development of the endemic fauna and flora. The remaining volumes are devoted exclusively to discussion of the Insecta. The groups covered in these volumes are:

Vol. 2. Apterygota–Thysanoptera
Vol. 3. Heteroptera
Vol. 4. Homoptera: Auchenorhyncha
Vol. 5. Homoptera: Sternorhyncha

ELWOOD C. ZIMMERMAN, Insects of Hawaii. Published by the University of Hawaii Press. Price per set, paper, $24.00. May also be purchased as single volumes: Vol. 1, $3.50; Vol. 2, $5.50; Vol. 3, $4.50; Vol. 4, $4.50; Vol. 5, $6.00. Orders may be sent to University of Hawaii Press, P. O. Box 18, Honolulu 10, Hawaii.

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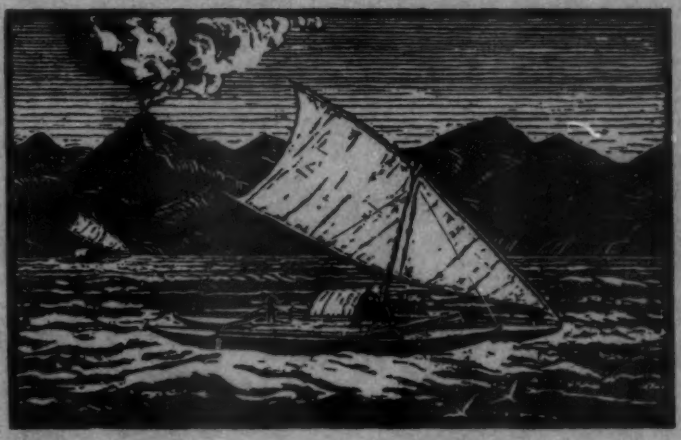

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